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FINAL BOSTON REDEVELOPMENT AUTHORITY ENVIRONMENTAL IMPACT REPORT

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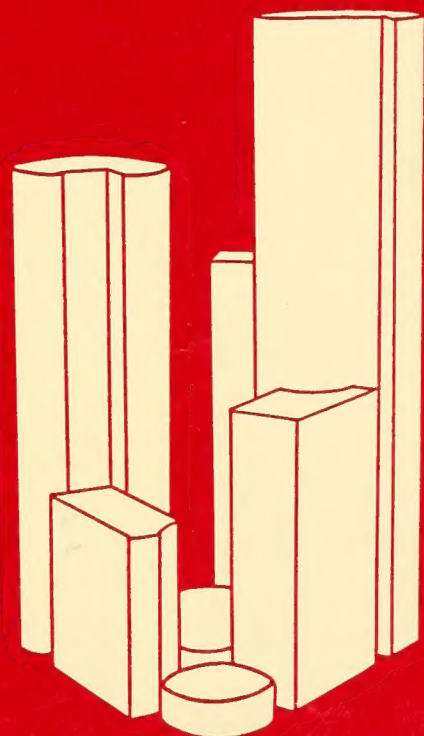
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International Place at Fort Hill Square



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P-FEIR

Prepared for The Chiofaro Company

Prepared by HMM Associates, Vanasse/Hangen Associates,
Colorado State University, Cosentini Associates and Haley & Aldrich, Inc.

FINAL BOSTON REDEVELOPMENT AUTHORITY
ENVIRONMENTAL IMPACT REPORT

INTERNATIONAL PLACE
at
FORT HILL SQUARE

November 1984

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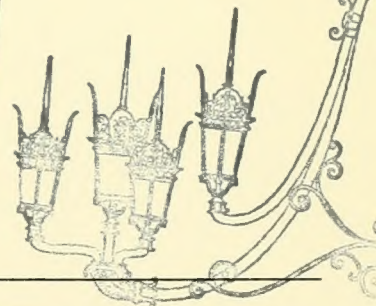


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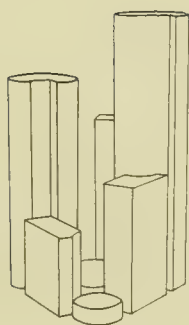
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TECHNICAL APPENDIX (2 versions issued -

one is Vol. 2 of This report - The other just says
Technical Appendices - each seems to be different)

Executive Summary



EXECUTIVE SUMMARY

Introduction

This document is the Final Environmental Impact Report (FEIR) for International Place at Fort Hill Square prepared for the Boston Redevelopment Authority (BRA). The report is composed of eleven major sections. Section I contains correspondence from the BRA and an introduction to the project. Sections II through X are the individual environmental analysis sections, addressing noise, shadow, transportation, air quality, wind, historic resources, utility systems, energy demand, and natural resources. Section XI consists of responses to comments on the initial BRA Environmental Impact Report of May 1984. A Technical Appendix is provided as a separate volume.

Included in this FEIR are four new analyses which supplant original analyses from the May EIR. They are: Pedestrian Wind, Utility Systems (Sewer), Transportation, and Air Quality. The development has been the subject of separate state and city environmental reviews. With the exception of the Pedestrian Wind analysis, which is part of the city's review process and not the state's, the Sewer, Transportation, and Air Quality analyses contained in this report are sufficiently comprehensive to meet both the city and state requirements.

The reports have been compiled by a team of leading environmental and engineering specialists assembled by the Chiofaro Company specifically to undertake the required studies. The team consists of HMM Associates, as principal environmental consultants, Vanasse/Hangen Associates, as transportation engineers, Professors J.A.

Peterka and J.E. Cermak of Colorado State University, as wind engineers, Cosentini Associates, as mechanical and utility engineers, Haley and Aldrich, as geohydrology engineers, and John Burgee Architects, with Philip Johnson as project architects.

I. Project Description

International Place at Fort Hill Square is a major, mixed use urban development comprised of approximately 1,660,000 square feet. The project entails development of 1,560,000 square feet of office space, 100,000 square feet of retail space and approximately 800 underground parking spaces on 2.6 acres of land bounded by Oliver Street, Purchase Street and High Street in Boston.

The project's distinctive design is composed of two cylindrical, high-rise towers, three rectangular building elements of varying heights and shapes, and two ground level enclosed public areas. Classic Palladian windows, similar to those found throughout Boston, are used extensively in the buildings, as are grand, arched entrances. Granite and glass are the primary building materials.

The taller of the towers is a 46 story structure augmented by two lower rectangular elements of 19 and 27 stories. The second tower is 35 stories tall with a connected rectangular element of 11 stories. Joining the two towers will be a glass-covered courtyard of approximately 25,000 square feet open to the public. It will feature a fountain, tropical landscaping and seating. The courtyard will also have cafes and retail activity reflecting the ambience of a European market square. Retail storefronts will ring the project perimeter along High and Oliver Streets.

II. Noise

The project has little effect on the noise environment in the Fort Hill Square area. Construction noise problems are minimal since no pile driving is required during the construction of International Place. Peak construction noise is associated solely with the operation of excavation equipment and heavy trucks. The operation of this equipment will not result in significant increases in noise levels above those associated with the commercial and transportation activities and ongoing construction activities predominant in the area.

The completed project will include no unusually noisy equipment or operations. Mechanical systems are sited such that their noise intrusion will be imperceptible. Indirect generation of traffic noise is also minimal.

III. Shadow Analysis

The two cylindrical towers of International Place will cast shadows to the north, east and west of the Fort Hill site. For the most part the tower shadows will be superimposed upon the shadows of existing buildings in the financial district. Little new net shadow will take place.

The Boston Redevelopment Authority (BRA) is particularly concerned about shadows on the Quincy Market and the Waterfront Park area. No new shadows are cast in these sensitive areas by the project. The studies also show that relatively few new shadows will fall on the already shaded streets of the Historic District adjacent to the project site.

IV. Transportation

International Place will generate approximately 13,000 to 14,000 two-way person-trips per day. Just over 70 percent

of these trips are expected to be by public transportation and pedestrians. The remaining 29 percent of the trip generation will result in 2300 to 2400 two-way vehicle trips to the site each business day. Approximately 17 to 18 percent of the vehicle trips will be made during the morning and evening peak hours. The project is expected to have a minimal impact on peak hour travel due to several factors. A proportionately small number of vehicle-trips will be added to the network. The project's proximity to the Central Artery will minimize the number of project-related vehicles added to the local street system. In addition, the spatial location of available parking sites will tend to spread the site related trips over the entire network.

A large number of pedestrians is anticipated. The project is being designed to attract and accommodate the expected pedestrian traffic volumes which will come to the site to work, eat, or shop. In addition, International Place will benefit from, and add to, the improved connection from Atlantic Avenue to Purchase Street that is a result of recent Dewey Square planning studies.

Easy access to public transportation will result in a high proportion of mass transit users. The transportation engineers have concluded that the MBTA and commuter rail facilities that surround the site can accommodate the passenger demands the project will create. The dependence on public transportation is consistent with City and State efforts to discourage the use of private automobiles for commuting into Boston.

V. Air Quality

Air Quality impacts related to International Place will not interfere with the attainment and maintenance of

standards designed to protect public health and welfare. An analysis of local air quality from project-related traffic demonstrated no violation of Massachusetts and National Ambient Air Quality Standards for carbon monoxide. Predicted levels of motor vehicle emissions for on-site parking facilities indicate small net emission increases in the project area due to International Place. Temporary emissions of fugitive dust from construction related activities will not be excessive. Measures to reduce dust emissions and minimize impacts will be strictly enforced. Overall, the project will modify air flow so that the mixture and dilution of pollutants with upper levels will be enhanced.

VI. Pedestrian Wind Levels

International Place generally increases wind speeds immediately adjacent to the project site. It also decreases wind levels at eleven locations. The introduction of the complex will alter the effective gust velocities primarily on the streets and sidewalks immediately abutting the site. At these locations winds will be increased, but the expected increases will result in acceptable conditions for pedestrian level activity. No passive recreation areas are affected and the streets remain suitable for pedestrian traffic.

The design has no unique characteristics which exaggerate pedestrian level winds. On the contrary, the wind tunnel results indicate the smooth cylindrical shapes of the high-rise elements help minimize potential for increases in pedestrian level winds.

Therefore, test results lead to a conclusion that predicted pedestrian winds resulting from International Place are not excessive for Boston, and should not create an unpleasant pedestrian environment.

VII. Historic

International Place is situated in close proximity to the Custom House Historic District. The project design is sensitive to the character of the district. Neither direct nor indirect adverse impacts to any historic building are anticipated. The project's presence will help revitalize the neglected southern part of the district.

VIII. Utility Systems

The Fort Hill site is adequately served by the Boston Water and Sewer Commission water lines. There is ample supply and capacity to provide both domestic water service and fire protection. The project design also specifies low-flow plumbing fixtures to conserve water.

The existing sewer system in the Fort Hill Square area surcharges when peak loads interact with tidal influence. During heavy precipitation the combined sewers also overflow into Boston Harbor. Until proposed MDC and BWSC improvements are constructed, the project will utilize a waste disposal system that stores sewage on-site and times its discharge to prevent additional surcharging during high tides. The project also provides for separation of its sanitary and storm runoff sewer loads.

IX. Energy

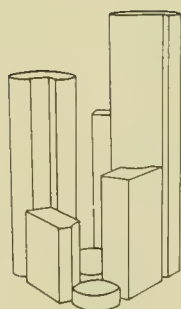
Mechanical engineers have designed an all-electric project after studying varying life-cycle costing options for alternative energy source for various building functions. The project has been designed for maximum energy efficiency. Total energy demand is about 17,000,000 KWH annually. Project systems meet all, and exceed most, of the applicable energy code levels. By using an advanced

lighting system, substantial energy will be conserved. Boston Edison has indicated that it has sufficient power reserves to meet the needs of all project systems.

X. Natural Resources

The existing soil conditions of the development site are appropriate for the construction and operation of International Place. The site surface consists of man-made, impervious cover. There are no natural resources to be disturbed or relocated. There is ample load bearing capacity in the soils and the site is free of subsurface water problems. The geohydrology engineers will establish a groundwater monitoring program to ensure that no unforeseen changes in the water table occur during or after construction.

BRA Correspondence and Project Introduction



Boston Redevelopment Authority

Stephen F. Coyle/Director

November 8, 1984

Fort Hill Square Associates
c/o Mr. Donald Chiofaro
The Chiofaro Company
One Post Office Square
Boston, MA 02109

Dear Mr. Chiofaro:

As part of the Boston Redevelopment Authority's review of the International Place development, the Authority has reviewed the Environmental Impact Report which you have submitted to us pursuant to our environmental review requirements for major development projects.

International Place at Fort Hill Square (the "Project") is a mixed-use development project to be constructed by Fort Hill Square Associates ("FHSA") on the 2.6 acre site bounded by High, Oliver and Purchase Streets in Boston's downtown financial district (the "Project site"). The Project site consists partly of privately owned land and partly of land now owned by the City of Boston. In accordance with a Sale and Construction Agreement dated May 30, 1984 by and between the City of Boston and FHSA, the Project is subject to design review by the Boston Redevelopment Authority ("BRA") acting as agent for the City and in its municipal capacity as the Planning Board of the City of Boston under St. 1960, C. 665, §12.

As the BRA is acting with respect to the Project only in its municipal planning board capacity and not as a state redevelopment authority under Chapters 121A and 121B of the General Laws, the actions of the BRA are not subject to the Massachusetts Environmental Protection Act, G.L. c. 30, SS et seq. Nevertheless, the BRA has required the developer to prepare a report analyzing all environmental impacts of the Project. The scope of the environmental report was set forth in a March 28, 1984 letter from the Authority, a copy of which is attached hereto for reference.

An environmental report was submitted by FHSA in May 1984. On May 27, 1984 the BRA published notice in the Boston Herald of the availability of the report, scheduling of a public hearing on the report for June 8, 1984, and the opportunity to submit written comments until June 26, 1984. A public hearing was conducted on the environmental report by the BRA Board on June 8, 1984. The comment period was subsequently extended until July 27, 1984.

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The development team and the BRA design review staff have been engaged, since designation of the developer last October, in design measures that would mitigate possible adverse impacts, particularly in the areas of shadow, wind, and traffic.

Concerning massing and density, substantial size reductions have taken place in the design development stages of the project. Initially, the taller of the two towers was located at the intersection of High and Purchase Streets. It has been moved to the Oliver and Purchase Street corner of the site where it will have less shadow impact on the Financial District, the Broad Street area, and public areas along the waterfront. The massing of the project originally called for two towers of 51 and 44 stories. They have been lowered to 46 and 35 stories respectively. In the spring of 1984, the massing of the lower tower stood at 36 stories, but shadow studies indicated that a one-story reduction would have beneficial sunlight impacts near the intersection of Milk and India Streets resulting in the final 35 story height. The rectangular elements, originally at 31 and 15 stories were also reduced to 27 and 11 stories respectively. In deference to the Chadwick Leadworks building on High Street, the lowest element of the International Place project is now opposite.

In comparison with the original proposal, the density of the approved massing has dropped dramatically. The developer's initial proposal called for an FAR of nearly 23. In the designation, it was reduced to 16. In square feet, this means a reduction of 320,000 feet from an original 2,170,000 to 1,850,000 square feet. The project as presently outlined in the design review documents equates to a project of 1,657,000 square feet of building area and an FAR of approximately 14.3.

It must also be noted that, as a result of the above reduction in building massing through the environmental and design review process, the views from other buildings will benefit from the widened space between the towers, satisfying a design guideline minimizing view blockage.

With regard to improving pedestrian flow and access, the developer and the Authority have widened sidewalks to a minimum fifteen foot width. Pedestrian access to the project has been improved by increasing the number of entrances to the courtyard and office elements and by aligning them with the entrances of surrounding buildings as well as with the end of Batterymarch Street. The development team is also continuing to test wind mitigation steps in the form of canopies and trees to see what effect they will have on pedestrian wind.

Concerning roadway and traffic improvements, International Place was originally designed leaving the existing High Street ramp from the Central Artery in place. As a condition of tentative designation, the development team has agreed to cooperate in relocating this ramp to a realignment along Purchase Street, a step considered by the Authority and State officials to be beneficial to downtown traffic patterns.

Mr. Donald Chiofaro

November 8, 1984

Additionally, the traffic flow in the immediate area will be improved as a result of design changes that move all truck docks underground, eliminating truck queueing along Purchase Street. The approved design also has resulted in relocating public parking access from the corner of High and Purchase Streets to a preferred location on Purchase Street. Traffic exiting from the underground service and parking areas of the project will be from four lanes rather than an original ten, resulting in a smoother integration of project traffic into the city pattern.

The Authority herein affirms that the Environmental Impact Report for the above-referenced Project, dated May 1984, does comply with the scope of impacts described in the Director's letter of March 28, 1984, and is prepared in accordance with the procedures of the Authority and other requirements concerning the protection of the environment applicable to the Project.

The Report also has been made available to other public agencies, including the MEPA office, and to interested individuals and groups which have requested copies. As a result of this review, we have received a number of comments on the EIR. A copy of the Authority comments are attached for your attention.

Promptly after this letter, you should submit to the BRA responses on the EIR. In preparing your responses, you should work with appropriate Authority staff. In addition, since you also are requested to submit a more limited Impact Report to MEPA, your responses to the comments should reflect the scope and comments concerning the MEPA document.

A final Environmental Impact Report, including the approved Environmental Impact Report and your responses to the comments, should be submitted to the Authority, which report must assure the Authority that all feasible means and measures heretofore recommended by the Authority to avoid or minimize adverse environmental impacts have been adopted.

In closing, I would like to reaffirm that the Authority's design review process, which has led to numerous mitigating measures, is an ongoing process and that further design review, in accordance with the Authority's standard design review procedures, will be required for the second phase of the project.

Sincerely
BOSTON REDEVELOPMENT AUTHORITY



Stephen Coyle
Director

International Place - Comments on Draft Environmental Impact Report

Noise

Future noise levels resulting from the project (including traffic generated) do not appear to be a significant problem since they are projected to be less than or only slightly greater than, existing levels and are within the normal range for downtown areas.

Transportation Analysis

Since the submission of the EIR to the Boston Redevelopment Authority, an expanded Transportation analyses was submitted to the State, the BRA assumes that level of analysis in the MEPA EIR is the basis for a final BRA EIR and therefore submits the following comments pertaining to the MEPA EIR.

1. In general, the transportation section in the MEPA EIR is an improvement over the same section in the BRA draft. Many of the deficiencies found in the BRA document have been corrected, except as noted below. The major improvement is that now the no-build and build scenarios are comparable, since both assume the relocation of the High Street off-ramp and thus the impact of the project can be more readily seen (as opposed to trying to determine what is due to circulation changes and what to the project).
2. It is still not clear whether existing trips to and from the site have been eliminated from future conditions or not, and whether the International Place traffic is the total traffic generated by the project or is new traffic (in addition to the traffic now generated by the site. This is not explicitly stated in the EIR. As an example of this problem, the A.M. peak-hour generation of International Place is given as 770 vehicles (Table 22). But according to Table 24 (which obviously includes some double-counting) peak-hour project-generated traffic is considerably lower and certainly does not reflect the fact that the project includes a 827-car garage. What happens to the majority of the project-generated traffic? Or is the analysis only talking about net increases?
3. On Page 8, A.M. and P.M. peak hours should be identified.
4. Figure 5 shows the Federal Street garage with 950 spaces whereas Page 13 states 900 spaces; this should be clarified.
5. (Table 1, footnote) - If there are 177 surface spaces on the site (Figure 5) then 660 (garage) and 177 equals 837 spaces, not 827. Which (827, 837, 887) is used for the analysis?
6. On Page 16, it should be noted that the Dewey Square Tower clearly falls within a 2,000-foot radius of the project site (see Figure 7).

7. The trip numbers on Table 7 should be verified. For example, Route 301, 301-1 is shown as having a bus leave during the P.M. peak period every 2 minutes, which is very questionable.
8. On Page 54, it should be noted that the P.O. Square Garage project has completed its State environmental review process (EIR not required).
9. A map indicating trip distribution percentages by highway route would be helpful (Page 83).
10. On table 24, why is the P.M. peak hour traffic for Atlantic Avenue north of Northern Avenue higher without the project than with?
11. On Figure 16, the route from the High Street ramp does not agree with the text (P. 94) (Broad Street is not shown).
12. Neither Table 26 nor Figure 17b. shown any change in LOS (or V/C ratio) for Atlantic Avenue/State Street during the A.M. peak between the No-Build and Build conditions (Page 104).
13. On Page 111 (last paragraph), should "off ramps" should be "on-ramps".
14. On Page 119, it is neither accurate nor reasonable to say that there is no congestion on the Arborway Line during rush hours.
15. It is not clear that all 1,500 parking spaces at North Station would be public (Page 127). A substantial number (800) currently are programmed to be reserved for MGH.
16. Does the traffic (LOS) analysis take into account the proposed pedestrian signal at Atlantic Avenue/Purchase Street?

Air Quality

The air quality analysis presented to the BRA has been expanded and modified in the DEIR submitted to the State. A revised air quality analysis based on the State DEIR should be included in the final BRA EIR. Therefore, the following comments are submitted concerning the MEPA DEIR Air Quality analysis.

1. On Page 6, peak-hour time is not given in the Transportation Section (also, there is no Section 5.2, which is repeatedly referred to in the text).
2. On Page 7, it does not appear that the speeds used in the analysis (see Tables A.5 and A.6 correspond to the conditions predicted at the analyzed intersections. Speeds used for these sites should be less than or equal to 10 mph (As noted in the Transportation Analysis comments, most of these intersections actually have LOS F).

3. As in the Transportation Section, it is unclear whether the increase in CO emissions is due to a net increase in traffic because of the project or to the total project-generated traffic (Page 177). This should be clarified.
4. On Pages 18-22 the parking facility analysis (Build) appears to consider only cars entering and existing the garage. Have trucks also been included in the analysis?
5. Since both air intakes and the exhaust vent will be located on Purchase Street, what precautions will be taken to prevent exhausts from being drawn into the air intakes?

Pedestrian Wind Analysis

The wind impact analysis indicates that there may be increased and uncomfortable winds created at some locations. At over half of the locations tested, winds will increase. The project enhances and the Phase I park area are indicated as locations which will be extremely windy.

In the Final EIR, the wind analysis must be augmented to consider specific mitigation measure testing. The May 31, 1984 BRA design development approval letter required that mitigation measures be studied in an effort to mitigate the adverse impacts of winds at street level.

Historic/Archaeological Impacts

There are several impact areas where effects on the adjacent historic properties are potentially adverse. Specifically, some shadow effects, pedestrian level winds, and traffic impacts may adversely impact the historic properties adjacent to the site. Therefore, the comments presented for those specific sections are referenced as they relate to the historic area.

The final EIR should also include support for the conclusion that no archaeological investigations are warranted.

Utilities

No discussion of, or commitment to, conservation measures to reduce water demand/sewerage generation is contained in the EIR. Since there is a potential for a deficiency in the City's water supply by 1990, investigation of, and commitment to, conservation measures must be included in the Final EIR.

The Boston and Sewer Commission noted that sufficient information to determine the project's effects on its system was lacking, particularly with respect to the storm drainage system. More detailed data respecting peak and average demands, adequacy of the existing utility systems, and overflow potential are included in the MEPA EIR. The following comments are presented relating to the State DEIR on sewer systems:

1. On Page 4, the text states that the northern part of the Oliver Street sewer is 24" x 18"; Figure 5.1.5 shows 24" x 16". Which is correct?

2. The Purchase Street sewer routing on Figure 5.1.2 does not correspond to the text description of the route (Page 6).
3. On Tables S.1.2 and S.1.3, standards/criteria need to be given for comparative analysis purposes. There is nothing which describes the water quality or what parameters are being exceeded.
4. The project includes 1,700,000 sf. of office space (not 1,800,000 sf.) and 100,000 sf. of retail space/restaurants. How do retail/restaurant sewerage loads compare to office loads and what impact will these have on total loads (pp. 23-24)?
5. If O'Brien and Gere use a factor of 75 gal/person (rather than 75 gal./1,000 sf. office space) to estimate areawide dry weather flows, and since there are approximately 5 persons per 1,000 sf. of office space, is sewerage flow from the project being underestimated (pp. 32-34)?

Energy

This section of the EIR is acceptable, no environmental issues have been identified during the review.

Natural Resources

Although the text did not indicate any substantial environmental problems, backup data and studies were only referenced and not included in the EIR. For the Final EIR, the following should be included:

1. The results of more detailed soils investigations noted in the Draft EIR, including monitored groundwater levels (the actual studies also should be included as an appendix).
2. A plan indicating the location of the groundwater observation wells to be installed prior to project construction.
3. More detailed information and analysis of the potential effect on surrounding buildings of a lowering of groundwater levels.
4. A description of the measures which will be taken during construction should a change in groundwater levels occur or other problems arise.

Boston Redevelopment Authority

Robert J. Ryan/Director

March 28, 1984

Mr. Donald Chiofaro
The Chiofaro Company
One Post Office Square
Boston, MA

Dear Mr. Chiofaro,

As part of the Boston Redevelopment Authority's review of the International Place development, the Authority requires submission and approval of a comprehensive environmental impact report.

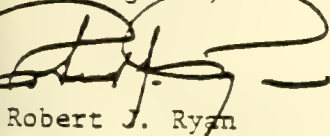
Prior to final designation by the BRA Board and concomitant with design review, you will be required to submit the reports which are listed on Attachment A. Approval of these reports will be required before final developer designation.

Environmental reports submitted to the BRA will be made available to other public agencies as well as to any interested individuals or groups requesting them.

Please work with my staff in coordinating the content and timing of the environmental reports with the ongoing design review process.

We look forward to continuing our cooperative review with you during the coming months.

Best Regards,



Robert J. Ryan
Director

ATTACHMENT A

INTERNATIONAL PLACE - REQUIRED ENVIRONMENTAL STUDIES

1. Pedestrian-level wind impact

- (a) Preliminary (qualitative) analysis to determine relative impacts and potential problem areas.
- (b) Wind tunnel testing of pedestrian and public areas (entrances, plazas) and of potential problem areas adjacent to and in the vicinity of the project site (wind influence area).
- (c) Identification of mitigation measures.

Maximum acceptability criteria = effective gust speeds of 31 m.p.h. no greater than 1% of the time.

2. Shadow impact

Time periods of interest: 10 a.m., 12 noon, 2 p.m., 4 p.m. (June 21 only)

Seasonal periods of interest:

Summer solstice	22 June
Winter solstice	22 December
Spring/Fall equinoxes	21 March and 23 September
	21 October

The study should distinguish additional and overlapping shadow caused by the project.

3. Transportation impacts

(a) General

Project generation (daily and peak-hour).
Modal split.
Regional distribution.

(b) Vehicular traffic

Circulation and access-impact on Central Artery and local street system and intersections.
Peak-hour travel demand (a.m. and p.m.).
Level-of-service analysis.
(Coordinate with Central Artery, Dewey Square studies)
Ramp changes.

(c) Parking

Parking requirements.

Effect on parking supply/demand distribution in area.

Public/private use of parking spaces.

Parking management plan.

(d) Pedestrian circulation

Demand/capacity analysis (pedestrian densities).

Connections to public transit stations/stops/terminals.

(e) Public transportation

Usage and capacity (rapid transit, bus, commuter rail).

Peak-hour demand/capacity.

(f) Truck service/deliveries.

(g) Construction period impacts.

Parking requirements (workers, equipment, trucks).

Truck access routes.

4. Air Quality Impacts

(a) Impact on local air quality from additional traffic generated by the project.

(b) Emissions from parking garage.

(c) Potential air flow modifications due to project elements, i.e blockage of the sea breeze and prevailing winds as they relate to pollution dispersion.

(d) Construction related impacts (demolition, site preparation, construction activities; construction traffic and equipment).

5. Noise impacts

(a) Potential noise from project operation, building mechanical systems, project-generated traffic.

(b) Construction-related impacts (construction activities, equipment).

6. Historic quality impacts

Potential impacts on adjacent and nearby historic properties (Broad Street District, Custom House Tower) - compatibility, scale, materials.

7. Utility systems impacts

Water usage, sewerage/solid waste generation.

Impact on water resources (supply/demand), disposal of wastes.

Measures to conserve resources/recycling.

8. Energy impacts

Energy requirements and impact on resources and supply.

Measures to conserve energy usage and fuel requirements.

Feasibility of including solar energy provisions.

Life-cycle costing analysis to determine efficient energy use.

9. Natural resources impact

(a) Potential effects on, or changes in, groundwater levels.

(b) Potential effects of ground (sub-soil) conditions.

N.B. IN ALL CASES WHERE ADVERSE IMPACTS ARE ANTICIPATED OR DETERMINED, MITIGATION MEASURES TO MINIMIZE OR AVOID THE ADVERSITY SHOULD BE IDENTIFIED.

I. PROJECT INTRODUCTION

1.1 Scope of Report

This report presents a comprehensive assessment of potential environmental impacts associated with the development of International Place at Fort Hill Square in Boston's Financial District. The Chiofaro Company, as developer, has initiated nine separate studies in recognition that several key environmental issues must be carefully considered in the design and development of this major project. These issues include: noise, shadows, traffic, air quality, wind, historic areas, utility systems (water and sewer), energy and natural resources.

The studies have been conducted since March 1984, and represent a current analysis of the project's impact. It should be made clear, however, that the study of impacts has been assumed by the development team as an ongoing responsibility. Analyses in this report refer to several studies that have been completed previously for the developer or for the Boston Redevelopment Authority's design review and environmental staffs which, in coordination with the Boston Society of Architects, have been conducting a design review of the project since late 1983.

Valuable assessments have also come from numerous groups and individuals with whom The Chiofaro Company has been maintaining communication. A conscious effort has been made to gather opinions from a variety of interests including abutters, historic preservation authorities, harbor and mass transit experts, labor, art and neighboring community representatives. The design as it stands today in large measure reflects input from these meetings which began more than three years ago.

Map of Downtown Boston



International
Place
at Fort Hill

1.2 Project Design and Description

Located on the block bounded by High, Oliver, and Purchase Streets, International Place is a 1,660,000 square foot complex on a 2.6 acre site. The breakdown of use is 1,560,000 square feet for office space and 100,000 square feet for retail. Five levels underground will provide more than 800 public parking spaces and contain all truck docks. Total project cost is estimated at \$414 million, and groundbreaking is scheduled for January, 1985. The Boston-based Chiofaro Company is the developer with the Hillman Company of Pittsburgh, Pennsylvania as the financial partner.

The design of architects Philip Johnson and John Burgee is distinguished by the use of seven building elements consisting of round and rectangular shapes of varying heights which "crash" into one another. Instead of the undifferentiated floors and windows usually found in larger buildings, International Place offers variety. Seven window styles will break up the granite facade. There are four distinct office floor sizes. Interesting nooks and crannies, resulting from the intersection of architectural shapes abound, as do entrances to the complex. In January, 1983, New York's Museum of Modern Art honored the design of International Place, along with two other foreign buildings, in an exhibition of advanced high rise architecture.

The elements step up from the glass enclosed main entrance, 45 feet tall, to the 600 foot cylinder of Tower One. On the southern corner of the triangular site, Tower One is intersected by rectangular elements of 27 stories along Purchase Street and 19 stories along Oliver Street. At the site's northern corner, Tower Two rises 35 stories along High Street.

Map of Project and Surroundings



International
Place
at Fort Hill

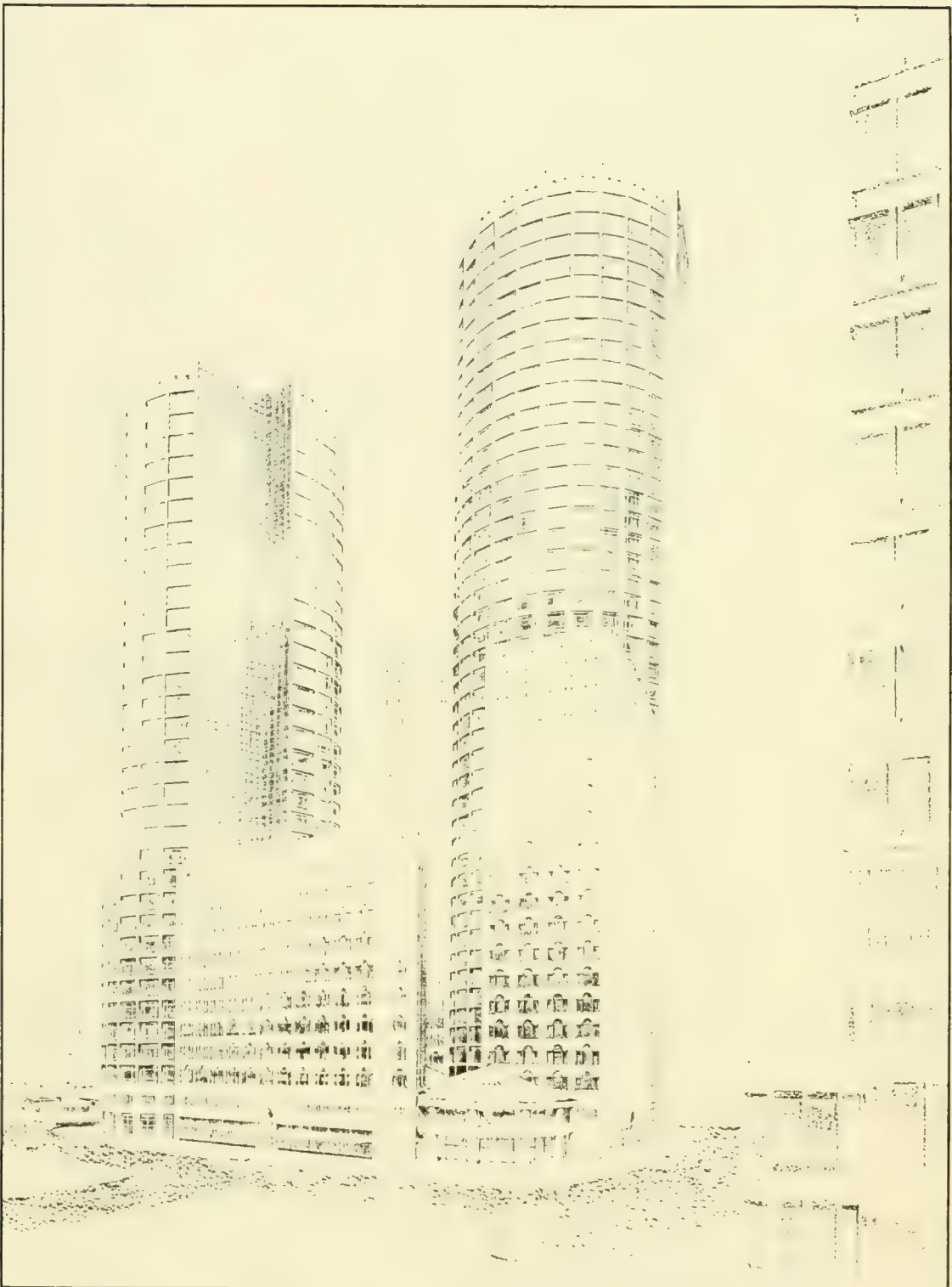
The grouping of slender cylindrical towers with shorter rectangles accomplishes two objectives that often conflict with each other in high rise architecture: the shapes form a dramatic skyline sculpture, and the open space between the towers preserves views of the harbor from other buildings.

In maintaining the character of the Financial District with buildings that hold the street line, Johnson and Burgee have also created an important inner space, a courtyard that fits between and is protected by the other building elements. It is a public place of more than 25,000 square feet covered by a glass roof. In contrast to the American high rise tradition of a building surrounded by a windy, and often barren plaza, this European-styled treatment of space within a complex of buildings fits comfortably into the downtown Boston architectural character. Johnson believes the courtyard will function like a piazza and has characterized the development as "a high rise, urban village".

1.3 Public Benefits

The climate-controlled courtyard is the most noticeable of numerous public benefits that International Place will bring to the immediate neighborhood and to the city as a whole. With amenities in the Fort Hill Square area in short supply, people will use the courtyard as a shopping resource as well as an indoor city park. It will have an active, bustling personality created by specialty shops, a fountain, landscaping, restaurants, cafes and places to sit and watch. Life will come to a heretofore neglected section of the city for 16 hours a day.

High and Oliver Streets—Full Project



International
Place
at Fort Hill

The development will have benefits that spread beyond the site to surrounding areas.

- o Its presence justifies the relocation of the Central Artery's High Street off-ramp onto Purchase Street, bringing benefits to the southern end of the Custom House Historic District and encouraging pedestrian access to the waterfront along an improved High Street.
- o It will help maintain the compact, efficient character of the Financial District where office demand is high and walking is the traditional means of transportation.
- o It will act as a gateway to future development in the Fort Point Channel area.

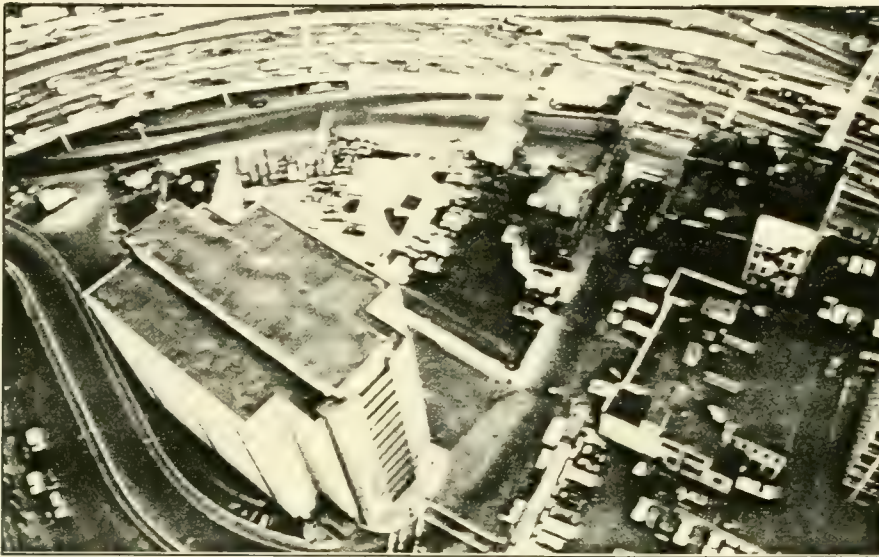
In addition, the project will make a substantial economic contribution to Boston.

- o \$25 million to the City to purchase the Fort Hill garage.
- o \$8 million in "linkage" funds for low-income housing.
- o \$12 million in annual property taxes, once the project is built, in comparison with less than \$500,000 produced for the City by the existing garage and private property.
- o 3,500 construction jobs over the five-year construction period.
- o 7,200 permanent jobs.

1.4 Site History and the Site Today

Since 1630, when the town of Boston was founded, Fort Hill has served many functions. Originally one of the three great hills, it was used as a fortification against

Existing Site



Aerial View



Pedestrian Level

International
Place
at Fort Hill

marauders from the sea to protect the new Boston. Through most of the seventeenth and eighteenth centuries, it served as pasture and common land until being fortified again during the Revolutionary War. In 1800, a park was established to anchor a planned housing area. Around the park, fashionable houses and two schools were built, lasting until 1866 when Fort Hill was leveled for fill between the wharves to construct Atlantic Avenue. This major earth moving project ended in 1872 at which time a new park was built as a center for the thriving trade and commerce developments taking place. With the construction of the Central Artery and the Fort Hill Garage, that character changed dramatically.

As it exists today, Fort Hill Square reflects little of its rich history. An antiquated and under-utilized mechanical public garage, a surface parking lot, and several dilapidated commercial buildings without historic value are now located on the project site. These structures will be demolished in connection with the project. Moreover, access to the site is now blocked by the existing Expressway downramp at High Street.

1.5 Future of the Area

It is uncertain at this time whether the Central Artery will be depressed or whether the High Street ramp will be relocated. However, the project has been designed to accommodate any of the following configurations.

- 1) Existing elevated Artery with High Street ramp relocated to Purchase Street.
- 2) Existing Artery with the existing High Street ramp.
- 3) Depressed Artery with access onto Purchase Street.

The Chiofaro Company and its engineering consultants meet regularly with public officials studying the proposed

The map illustrates the downtown Boston area, highlighting the following streets and landmarks:

- Streets:** Broad Street, High Street, Oliver Street, Purchase Street, Franklin Street, and John F. Fitzgerald Expressway.
- Landmarks:** Government Center, Central Business District, and North Boston.
- Subway Lines:**
 - Orange Line:** Indicated by a line with arrows pointing Northbound and Southbound.
 - Green Line:** Indicated by a line with arrows pointing Northbound and Southbound.
 - Blue Line:** Indicated by a line with arrows pointing Northbound and Southbound.

International Place at Fort Hill

changes and have agreed to cooperate with the City and State in seeking to relocate the ramp.

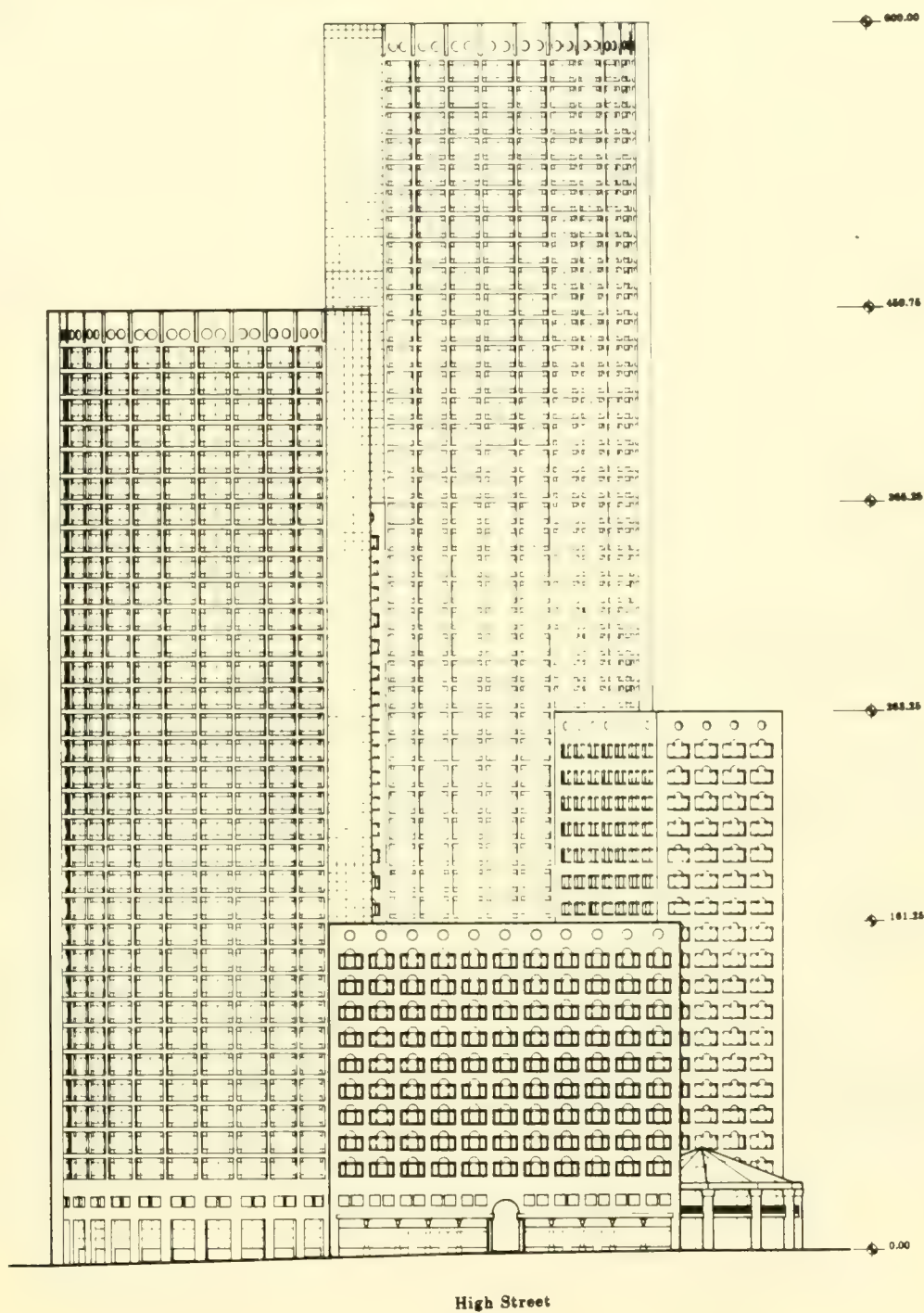
International Place will occupy an under-utilized corner of the intensely urban Financial District and be a neighbor to the State Street Bank building, the Travelers Insurance building, and two new office buildings at 260 and 265 Franklin Street. Demand for space in the District will continue to increase. Boston's traditional influence as a financial center is on the rise, accompanying the growth of high technology firms in the region and the desirability of the Boston area as a place to live.

It is in the city's interest to encourage good development that will maintain a healthy economic base and also contribute to Boston's charm and character. The architects and the developer are keenly aware of the public's desire to weave new development compatibly into the city's complex fabric. This has been underscored by the staff at the B.R.A., first in the competition to determine the best proposal for the site and then in the design review process itself, to which this report is contributing.

Architectural site plan of the proposed shopping center at the intersection of Battery Road and Oliver Street. The plan shows a large, irregularly shaped building complex with various sections labeled: "Greater Car Wash and Showroom" at the top; "Retail" and "Arcade" sections on the left; "Retail" and "Fresh Produce" on the right; and "Retail" and "Arcade" at the bottom. A central area is labeled "Sample in Showroom". The plan also shows "Greater Car Wash and Showroom" at the bottom left, "Fresh Air Intake Grille" at the bottom center, and "Streetlights" at the bottom right. The surrounding streets are "Battery Road" (top), "Oliver Street" (bottom), "Hill Street" (left), and "Purcell Street" (right). A "Proposed Ramp" is shown on the right side. The plan includes a scale bar (0 to 200 feet) and a north arrow. A legend indicates that the "Sample in Showroom" is a "Sample in Showroom" and the "Fresh Air Intake Grille" is a "Fresh Air Intake Grille".

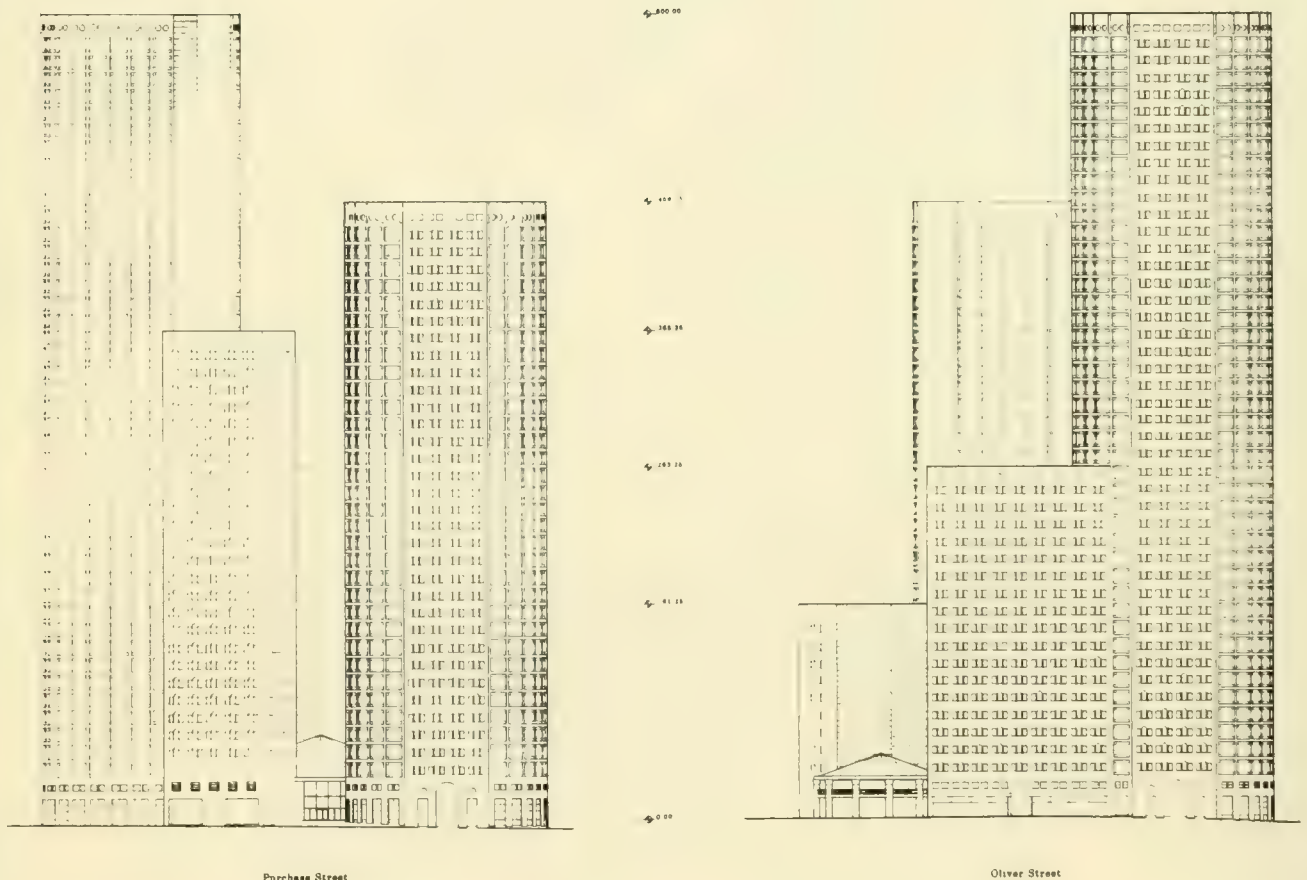
International Place at Fort Hill

Building Elevation—High Street



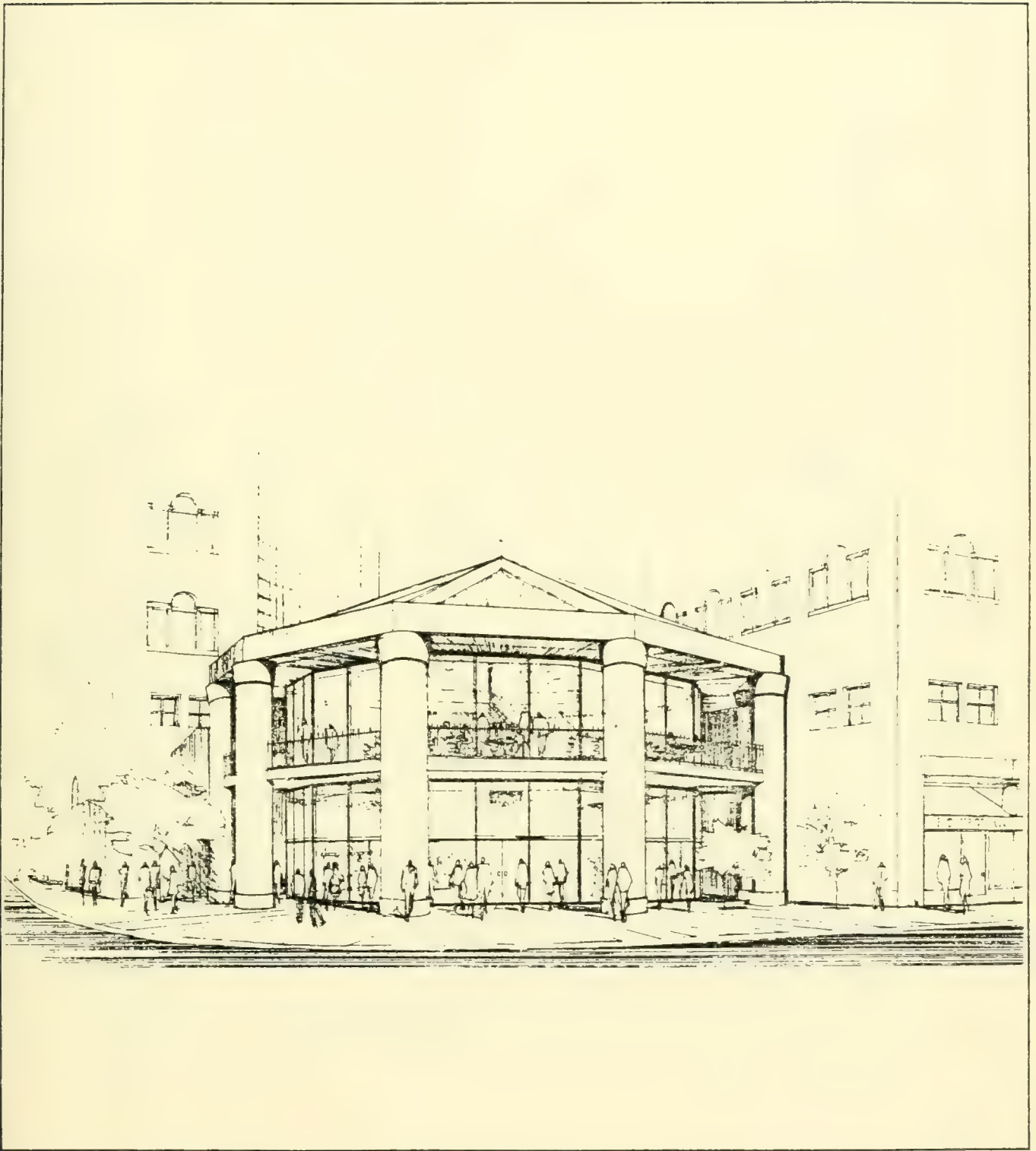
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Building Elevation—Purchase and Oliver Streets



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Main Entrance at High and Oliver Streets



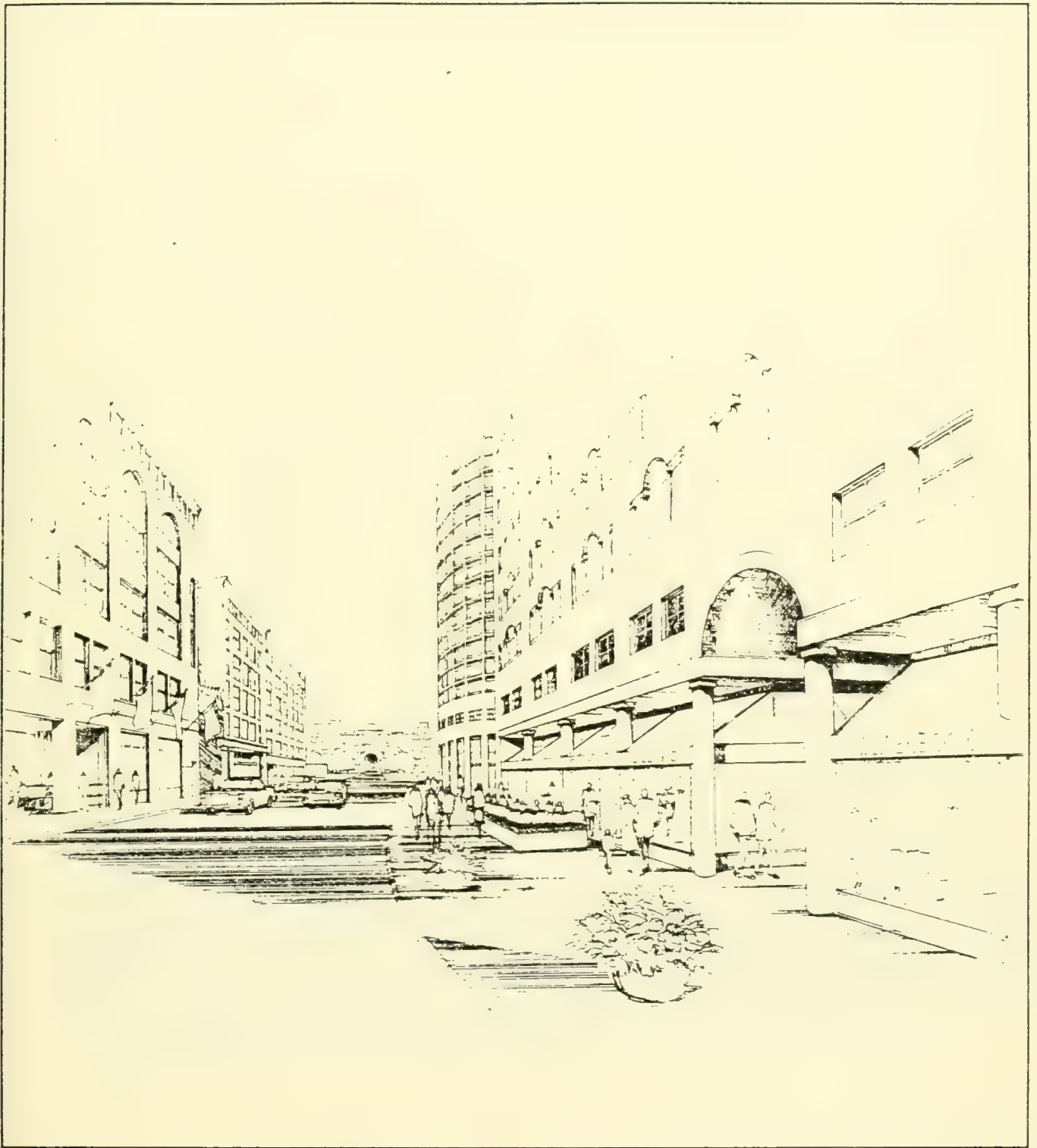
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High Street Perspective Study



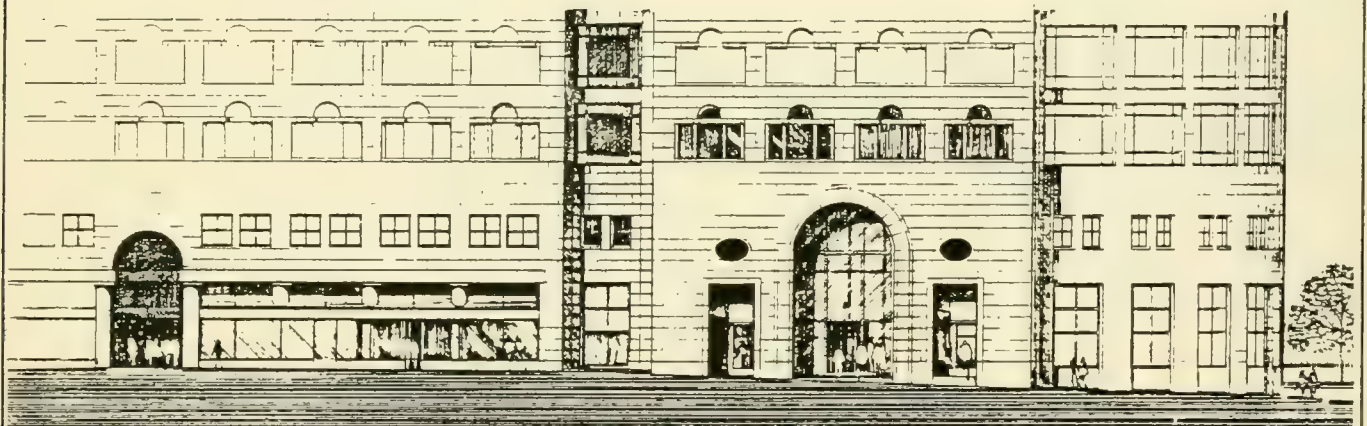
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High Street Pedestrian Level



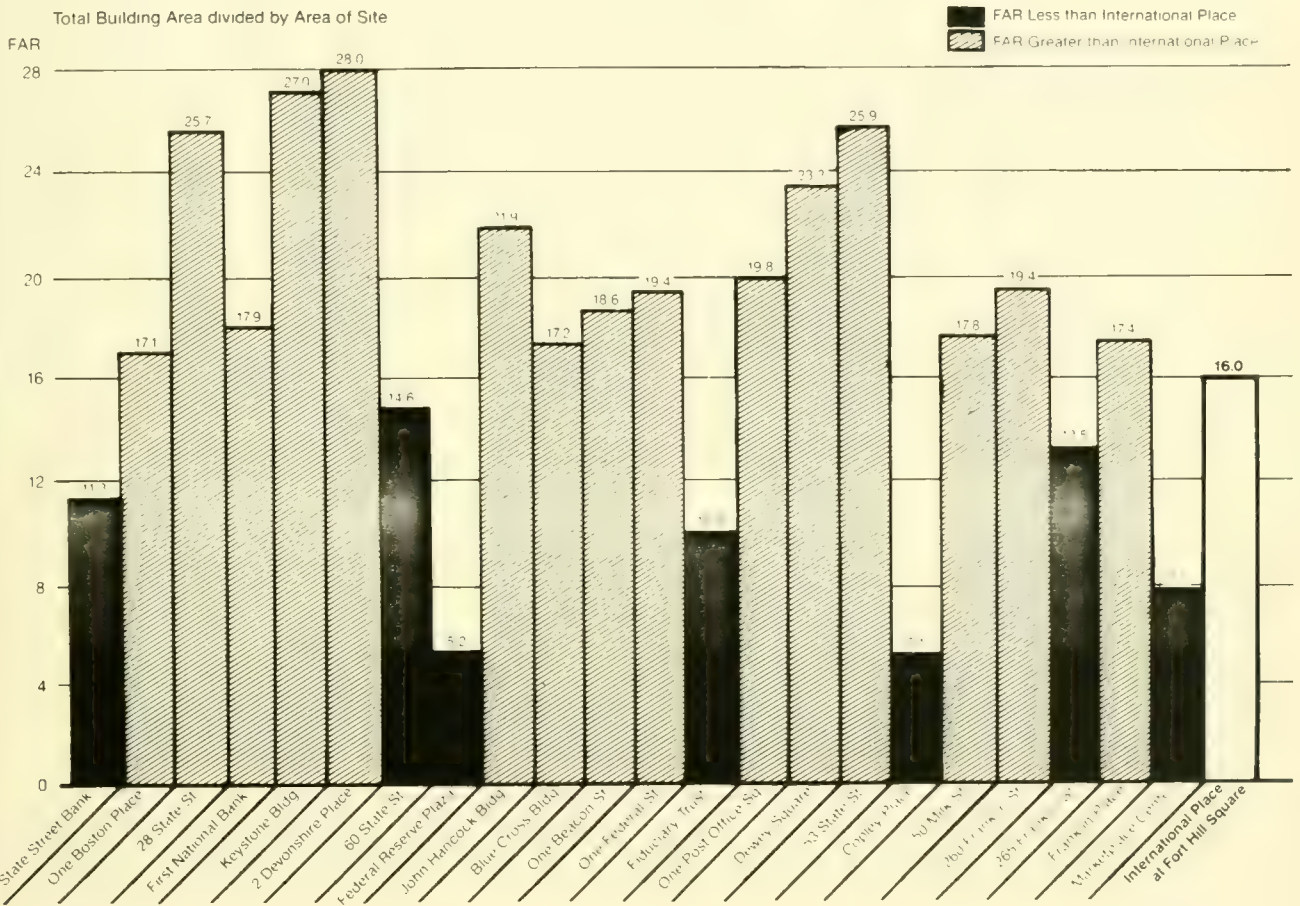
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Oliver Street—Pedestrian Level



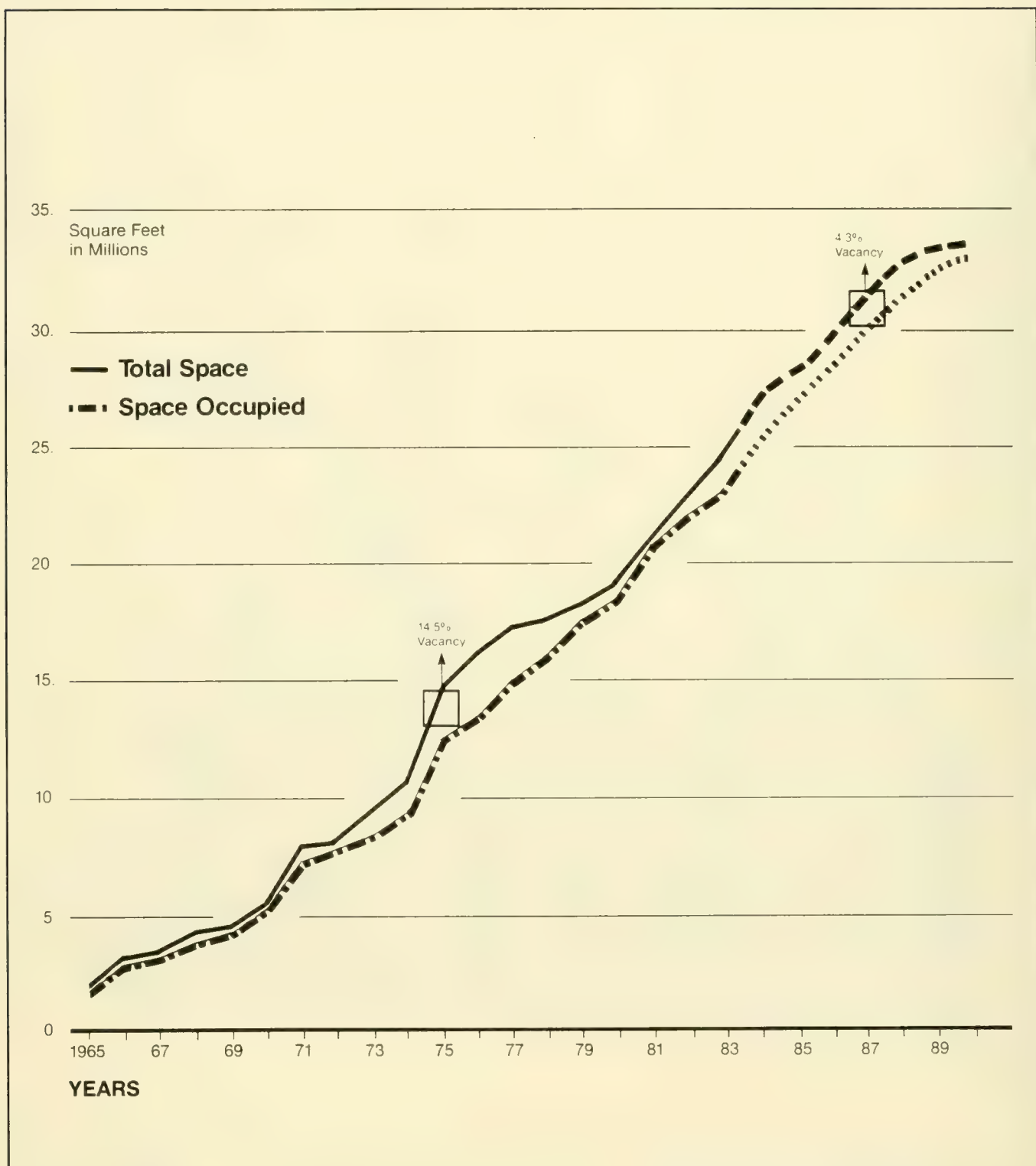
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Floor Area Ratios for Boston Buildings



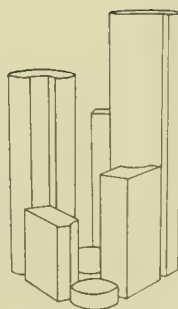
International
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at Fort Hill

Downtown Boston Office Market 1965-1990



International
Place
at Fort Hill

Noise Analysis



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Figure 2.1 Noise Study Locations

2. Noise Analysis

2.1 Introduction

A noise analysis was undertaken in the Fort Hill Square area to estimate future traffic, construction and operational noise level impacts associated with the International Place development. Existing noise levels were monitored during the peak afternoon traffic hour and the existing and future traffic noise levels for the No-Build and Build cases were modeled at two locations using the FHWA Traffic Noise Prediction Model.* A peak construction noise period was also modeled, as well as noise from mechanical systems once the development is in operation.

When assessing the impact of noise on people, background levels, noise peaks, and the fluctuation of the noise levels are generally considered. Non-steady noise exposures in the community are commonly expressed in terms of an A-weighted sound level (dBA) that is exceeded for a percentage of the measured time period. The term " L_x " is used to describe the sound level value that is exceeded for x percent of the time period under consideration. Following are two of the commonly used "percentile levels":

L_{10} = The noise level (dBA) that is exceeded 10% of the time.

L_{90} = The noise level that is exceeded 90% of the time. L_{90} is used as a measure of background noise.

* Federal Highway Administration, FHWA Highway Traffic Noise Prediction Model, FHWA-RD-77-108, Washington, D.C., 1978.

Another method of quantifying the noise environment is to determine the value of steady-state sound which has the same A-weighted sound energy as that contained in the time-varying sound. This is termed the Equivalent Sound Level (L_{eq}). The L_{eq} is a single value of sound level for any desired duration, which includes all of the time-varying sound energy in the measurement period. The major virtue of the L_{eq} is that it correlates reasonably well with the effect of noise on people, even for wide variations in environmental sound levels and time patterns. It is used when only the durations and levels of sound, and not their times of occurrence (day or night), are relevant.

The results of this analysis are reported in terms of the L_{eq} . L_{eq} is used by the FHWA in its noise standards and traffic noise prediction model and by the Environmental Protection Agency in its noise exposure guidelines, as it correlates reasonably well with people's perception of noise.

The noise environment of a typical urban community contains a nearly steady "background" noise resulting from industrial noise, commercial activity, heating and air conditioning equipment, other continuously operating machinery, and the multitude of motor vehicles throughout the city. Superimposed on the background is the noise from nearby cars, trucks, trains, planes, and noise from the general activity of people. Table 2.1 identifies noise levels associated with some common activities and sources of noise.

TABLE 2.1
COMMON NOISE LEVELS

<u>Sound Level (dBA)</u>	<u>Associated Activity</u>
130	Threshold of Pain
120	Chipping on Metal
110	Rock Band
100	Jack Hammer
	Jet Take-off (1/2 mile)
90	Threshold of Hearing Damage
80	Shop in Shipyards
	Busy Freeway
70	Downtown Traffic
	Electric Typewriter
60	Normal Conversation
	Urban Residential Area (Nearby Traffic)
50	Drafting Office
40	Suburban Neighborhood (Distant Traffic)
	Private Office
30	
20	Quiet Rural Area (No Traffic)
10	
0	Threshold of Audibility

Adapted from Acoustical Seminar, Robin M. Towne & Associates, 1971. (These values are approximate, and do not reflect specific situations described in this report.)

2.2 Study Locations

The International Place project area is dominated by commercial, office and industrial use. There is no residential use in the immediate area. The study locations were selected to reflect areas where the largest traffic changes are likely to occur in the future and where noise is more likely to affect a sensitive receptor. Sensitive receptors at both study locations are comprised primarily of work force pedestrians. Figure 2.1 shows the locations selected for analysis. Location 1 is at the northeast corner of the intersection of High Street

Figure 2.1 Noise Study Locations



International
Place
at Fort Hill

HMM Associates
Concord, MA

and Oliver Street. A parking garage is presently at this location, with other open parking lots and office buildings located in the immediate vicinity. The primary pedestrian access to International Place will be located at this corner. Location 2 is on the northern side of Oliver Street just west of its intersection with Purchase Street. Land use at this location adjacent to the Central Artery is composed of office space and some commercial establishments. Access to International Place will also be available at this location.

2.3 Existing Noise Levels

The project area is a general business district in downtown Boston. Local noise levels in the area consist of traffic, aircraft and pedestrian activity as well as building mechanical systems. In order to determine existing noise levels, an afternoon peak traffic hour monitoring study was conducted from 4:30 to 5:30 PM. The existing peak hour traffic noise levels were also modeled using the FHWA Highway Noise Prediction Model. This serves to validate model results compared to actual monitored noise levels. To model the existing afternoon peak traffic noise levels in the study area, traffic data and link geometry data between roadways and receptors (presented in Appendix F), were input into the FHWA Highway Noise Prediction Model. Adjustments as described in Appendix I of the FHWA model* were incorporated into the model, where necessary, to account for accelerating vehicles at intersections.

* FHWA Highway Traffic Noise Prediction Model, Appendix I "Interrupted Flow (Stop-and-Go Traffic)", FHWA-RD-77-108, Washington, D.C., 1978.

Noise level results for the afternoon peak hour of traffic are presented in Table 2.2. At Location 1,

TABLE 2.2
EXISTING AFTERNOON PEAK HOUR OF
TRAFFIC NOISE LEVELS (Leq)

<u>Location</u>	<u>Noise Model Results (dBA)</u>	<u>Monitored Results (dBA)</u>
1	67.5	69
2	71	73

monitored results show a peak traffic hour Leq of approximately 69 dBA while model results are slightly lower at about 67.5 dBA. At Location 2, monitored noise levels (73 dBA) are also slightly higher than the modeled results (71 dBA). These differences are attributed to the fact that the FHWA model calculates only traffic related noise levels while the monitoring program includes other possible noise sources in the area such as aircraft, building systems and general human activity. Existing noise levels presently exceed the City of Boston's noise standard of 65 dBA for business zoned areas.*

2.4 Future Traffic Noise Levels

Future afternoon peak traffic noise levels in the project area were estimated using the FHWA model used for existing noise levels. Traffic volume changes and roadway design

* From Regulation 2.5, City of Boston Air Pollution Control Commission, "Regulations for the Control of Noise in the City of Boston", effective January 1, 1972.

variations were input to the noise model to account for general traffic growth and government proposed roadway changes with two Build alternatives. Roadway changes for the first full Build alternative include High Street traffic flow being reversed to northbound, and closing of the High Street off-ramp with its relocation further south onto Purchase Street. The second full Build alternative includes the same roadway changes at High Street, an up ramp from a depressed Central Artery along with a new east/west roadway over the Central Artery connecting Oliver Street and Northern Avenue.

Table 2.3 presents the noise model results obtained for the two Build alternatives and compares these to the No-Build alternative and existing noise levels. Results show a 1990 No-Build increase of about 2 dBA at Location 1 and an increase of 1 dBA at Location 2 over existing levels. These changes are attributed to the general traffic growth that can be expected in the study area without the International Place development.

TABLE 2.3
EXISTING AND FUTURE PEAK TRAFFIC NOISE (Leq)
MODELED IN THE STUDY AREA (dBA)

<u>Location</u>	<u>1990 No-Build</u>	<u>1990 Build 1</u>	<u>1990 Build 2</u>	<u>Existing</u>
1	69.5	58.5	62	67.5
2	72	72.5	72	71

The roadway changes in the Build alternatives will greatly reduce traffic flow at the intersection of High Street and Oliver Street. This is due in part to the proposed relocation of the Central Artery off-ramp

currently entering this intersection. This ramp carries a high volume of vehicles which will be directed onto Purchase Street once it is relocated. Thus in the Build 1 alternative, this traffic volume reduction will result in a noise decrease at Location 1 of 11 dBA from the No-Build condition. The full Build 2 traffic noise levels will be about 62 dBA, or 7.5 dBA lower than the No-Build condition.

At Location 2, 1990 peak traffic noise levels will remain virtually unchanged with the No-Build and both full Build alternatives. Peak traffic noise levels will be approximately 72.5 dBA with the first Build alternative. Traffic noise with the second Build alternative, which includes the depressed Central Artery, will reach about 72 dBA. The reduction in noise realized with the depressed Central Artery would be counterbalanced by the increased traffic utilizing Purchase Street.

The project area, being a business district in downtown Boston, and being located adjacent to the Central Artery experiences moderately high noise levels. These noise levels will continue to increase through the International Place design year, 1990, due to general growth. With the project development and its associated roadway changes, future noise levels related to traffic are expected to decrease significantly at Location 1, the intersection of High Street and Oliver Street and the primary pedestrian entrance to the project. Traffic noise levels at Oliver Street, by the intersection of Purchase Street, will change very slightly compared to the No-Build case. These noise level changes will be imperceptible to pedestrians in the area.

2.5 Construction Noise Levels

In order to estimate peak levels of construction noise associated with this project, the construction schedule for International Place was examined. Overlapping phases of construction activity, along with the equipment usage for each phase, was analyzed to determine the peak level of equipment usage on-site. April 1985 was chosen as the period likely to produce peak construction noise levels. During this month, work related to both excavation, and foundation and wall construction, will be taking place. In order to estimate peak construction noise levels, all equipment used daily during both of these work phases was assumed to be operating simultaneously at a theoretical site center.

Table 2.4 presents the type and number of equipment pieces included as part of the construction noise assessment. Pile driving activities will not take place during any construction phase of the project. Since pile driving, and the use of heavy duty impact devices, is generally considered the major noise generating construction activity, the absence of this equipment is significant. The peak reference noise level at 50 feet from the site center and a daily usage factor were used to estimate the peak hour L_{eq} for each type of construction equipment. The noise levels associated with each piece of equipment were then added to calculate the total peak hour L_{eq} on the site. Noise levels at various distances from the site's center point were then determined. This information is presented in Table 2.4.

TABLE 2.4
ESTIMATED PEAK HOUR Leq DURING CONSTRUCTION (dBA)

<u>Equipment</u>	<u>Peak Reference Noise Level @ 50 Ft.*</u>	<u>Daily Usage Factor*</u>	<u>Equiva- lency⁺ Factor</u>	<u>Estimated Peak Hour Leq @ 50 Ft.</u>
4 Backhoes	85	.16	-8	77 (4)
8 Trucks	86	.1**	-9	77 (8)
1 Hoe-Ram (Pneumatic Tool)	86	.16	-9	77 (1)
2 Air Compressors	81	1.0	0	81 (2)
2 Chain Saws	78	.04	-6	72 (2)
1 Concrete Pump	82	.4	-4	78 (1)
4 Concrete Trucks	86	.4	-4	82 (4)
2 Clay Spades	85	.16	-8	77 (2)
1 Diesel Crane	83	.16	-7	<u>76 (1)</u>

Peak Hour Leq 50 feet from site center 92.5 dBA

Leq(h) @ distance = Leq ref. - 20 log D/D_o

D_o = 50 feet from
site center

Leq(h) @ 100 ft = 92.5 - 20 log 100/50 = 82.5 dBA

Leq(h) @ 250 ft = 92.5 - 20 log 250/50 = 78.5 dBA

Leq(h) @ 220 ft = 92.5 - 20 log 220/50 = 79.5 dBA

* Source: U.S. Environmental Protection Agency; Document NTID 300.1; "Noise from Construction Equipment and Operations, Building Equipment and Home Appliances," December 1971.

** Assumed value

+ Calculated using Table 2 from Highway Construction Noise Measurement, Prediction, Mitigation, U.S. DOT/FHWA, 1977. It is assumed that Lb = 70 dBA.

The peak construction noise level associated with the combined use of all the equipment pieces listed in Table 2.4 is approximately 92.5 dBA at a distance of 50 feet from the site center. Study Locations 1 and 2 are located at distances of approximately 220 feet and 250 feet from the site center, respectively. At Location 1, the peak construction noise is about 79.5 dBA, approximately 10 dBA higher than ambient noise levels in 1990. This will result in a total peak noise level of about 80 dBA during construction at Location 1. At Location 2, peak construction noise will be approximately 78.5 dBA or about 2.5 dBA higher than 1990 ambient levels, resulting in a total construction period peak noise level of approximately 79.5 dBA. These noise levels are representative of noise environments at urban construction sites.

Table 2.5 presents the City of Boston's construction site noise restrictions applicable to the International Place project site. In the project area, the construction noise Leq results of 79.5 dBA and 78.5 dBA correspond to an L_{10} of approximately 81 dBA and 80 dBA, respectively. A maximum L_{10} of 80 dBA for general business areas, and 85 dBA for industrial areas is stated in the city's Noise Regulation 3.1.

The use of equipment with mufflers in good condition, and the placement of temporary walls around the site will help mitigate construction noise levels. Pedestrians affected by the site's construction noise may seek alternate walking routes to avoid the noise and other construction activities. During normal working hours, when most people will be inside, the masonry walls and closed windows of buildings can be expected to produce a substantial noise attenuation of approximately 25 dBA for

TABLE 2.5
CITY OF BOSTON
SUMMARY OF RESTRICTIONS ON
CONSTRUCTION SITE NOISE*

Regulation 3.1 MAXIMUM LEVELS

<u>Land Use of Affected Property</u>	<u>Maximum Noise Level Value Measured at Lot Line of Affected Property (dBA)</u>	
	<u>L₁₀</u>	<u>Maximum Noise Level</u>
Residential or Institutional	75	86
Business or Recreational	80	--
Industrial	85	--

(To be evaluated at distances not closer than 50 feet from nearest active construction device, using slow response of sound level meter.)

Regulation 3.2 MEASUREMENTS

- o A-weighted
- o At 10-second intervals, 100 sample total
- o Measured L₁₀ must exceed background L₁₀ by 5 dBA for violation of 3.1

Regulation 3.4 Maximum levels under 3.1 do not apply to impact devices (pile drivers, paving breakers, riveters, etc.)

* City of Boston Air Pollution Control Commission, "Regulations for the Control of Noise in the City of Boston." Regulation 3, Effective January 1, 1972.

the comfort of occupants. Internal HVAC systems may further mask external noise sources.

2.6 Noise Levels from Mechanical Systems

There will be two locations for HVAC equipment. Cooling towers will be located at the top of the high-rise portion of the project. These will be at least 400 feet from street level and will have no noticeable impact on the ambient noise at street level.

The exhaust fans and intake louvers will be located on the second floor of the low rise portion of the project facing Purchase Street and the Central Artery. These fans have been located on the back side of the building immediately above the garage and truck entrance. The fan's intake and exhaust will be approximately 25 feet above grade. This will result in a fan noise component at street level of about 63 dBA, well below the ambient noise level of 72.5 dBA and 72 dBA calculated for the Build alternatives 1 and 2, respectively.

Noise levels with the fans in operation will be approximately 73 dBA with the Build 1 alternative and 72.5 dBA with the Build 2 alternative. This level of increase is insignificant and will not be perceptible to pedestrians in the area.

The location of the intake and exhaust louvers at the rear of the building facing Purchase Street and the Central Artery has been chosen specifically to mitigate impacts. This side of the site serves vehicular and truck access. It faces away from the downtown and is dominated by the Central Artery abutting the site. High Street and Oliver Street carry the majority of pedestrian activity in the area while Purchase Street is not generally used by pedestrian traffic, the sensitive receptor for this noise source.

2.7 Conclusion

In summary, International Place will have little long-term impact in an area that is already noisy because of its proximity to the Central Artery. Future traffic noise levels will experience no change due to the project at one studied location and a reduction at the other location. Mechanical system noise levels will be barely perceptible.

Normal increases in levels will be experienced during construction. However, mitigation measures are planned. The absence of pile driving during construction of the project will contribute to reduced levels as well.

APPENDIX A

FHWA NOISE PREDICTION MODEL INPUT DATA
AND
CALCULATION SHEETS

Input Data

Data provided in the Transportation Analysis (Section 4) of this report by Vanasse Hangen, the project's traffic engineers, was used as the basis for predicting traffic related noise levels in the project area. By a weighted average method, 4% of traffic on all roadways was assumed to be heavy trucks. Locations selected for analysis correspond to sidewalk areas. No sound attenuation barriers were assumed and all site characteristics were determined to be reflective. The reference energy mean emission level for all vehicle types was obtained from the National Reference Energy Mean Emission Levels as a Function of Speed*, except where traffic flow was considered to be stop-and-go. In this case, the reference energy mean emission level for each vehicle type was determined according to Appendix I - "Interrupted Flow", of the FHWA model.

The following pages contain calculation sheets for the four cases considered in this analysis.

* FHWA Highway Traffic Noise Prediction Model, FHWA-RD-77-108, Washington, D.C., 1978.

NAME Receptor #1 PM Peak
 DATE Cushing Case

PROJECT DESCRIPTION corner of Oliver Street and High Street

1	LANE NO./ROAD SEGMENT	A (v)			B (v)			C (v)			D (v)			E (v)			F (v)		
		high SB north of corner	high SB north of corner	high SB north of corner	high SB north of corner	high SB north of corner	high SB north of corner	high SB north of corner	high SB north of corner	high SB north of corner	high SB north of corner	high SB north of corner	high SB north of corner	high SB north of corner	high SB north of corner	high SB north of corner	high SB north of corner	high SB north of corner	high SB north of corner
2	VEHICLE CLAS.	A	MT	HT	A	MT	HT	A	MT	HT	A	MT	HT	A	MT	HT	A	MT	HT
3	N(vph)	525	-	22	308	-	13	459	-	19	199	-	3	18	-	1	76	-	7
4	S(km/h)	40.3	40.3	40.3	40.3	40.3	40.3	40.3	40.3	40.3	45.2	45.2	45.2	45.2	45.2	45.2	45.2	45.2	45.2
5	D(m)	39.3 m			25.7 m			30.5 m			1.3 m			1.6 m			5.2 m		
6	ϕ_1 (degrees)	Fig. 5			-17°			-19°			-67°			+67°			-84°		
7	ϕ_2 (degrees)	Fig. 5			+47°			+56°			-16°			+81°			-69°		
8	$(L_0)E_i$ (dBA)	Fig. 2						58.8			-87.0						60.7		
9	10 LOG ($N/D_0/S_i$) (dB)	Fig. 3						22.3			-8.5			18.2			-17.7		
10a	10 LOG (D_0/D) (dBA)	Fig. 4						-3.1									-0.1		
10b	15 LOG (D_0/D) (dBA)	Fig. 4																	
11a	10 LOG ($\psi_0(\phi_1, \phi_2)/\pi$) (dBA)	Fig. 6						-5.5			-7.3						-1.2		
11b	10 LOG ($\psi_{1/2}(\phi_1, \phi_2)/\pi$) (dBA)	Fig. 7																	
12	ϕ_L (degrees)	Fig. 10									R _n = 41 m								
13	ϕ_R (degrees)	Fig. 10									R _f = 82.8 m								
14	δ_0 (metres)	Fig. 9																	
15	N_0	Eq. 18																	
16	Δ_B (dBA)	Appendix B									-30			-30					
17	CONSTANT (dB)	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25
18	$L_{eq}(h)$ (dBA)	40.9	-	53.4	48.3	-	53.7	47.5	-	61.9	41.6	-	53.9	44.7	-	60.6	52.1	-	64.4
19	$L_{eq}(h)$ (dBA)	54.5			54.8			62.1			54.1			51.6			64.6		
20	Δ_3 (dBA)	Fig. 8																	
21	$L_{eq}(h)$ (dBA)																		
22	$L_{eq}(h)$ (dBA)																		
23	ND/S (m/km)																		
24	$(L_{10} - L_{eq})_i$ (dB)	Fig. 15																	
25	$L_{10}(h)$ (dBA)																		
26	$L_{10}(h)$ (dBA)																		
27	$L_{10}(h)$ (dBA)																		

Noise Prediction Worksheet

$L_{eq} = 67.4$ dBA

NAME Receptor #2 PM Peak
 DATE Existing Case

PROJECT DESCRIPTION Corner of Purchase Street and Oliver Street
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		A (°)			B (°)			C (°)			D (°)			E (°)			F (°)		
1	LANE NO./ROAD SEGMENT	On-ramp 45 to rt. R. Purchase St			On-ramp 50 to rt. R. Purchase St			Purchase St 50 north of 45th			Purchase St 50 south of 45th			On-ramp 50 to Highway 40			Highway 50 at rt. R. Purchase St		
2	VEHICLE CLAS.	A	MT	HT	A	MT	HT	A	MT	HT	A	MT	HT	A	MT	HT	A	MT	HT
3	N(vph)	18	-	1	125	-	5	1132	-	47	1238	-	52	864	-	36	5176	-	28
4	S(km/h)	45.2	45.2	45.2	45.2	45.2	45.2	45.2	45.2	45.2	45.2	45.2	45.2	40.3		41.3	40.3		40.3
5	D(m)	4.3 m			9.0 m			16.3 m			25.0 m			31.3 m			42 m		
6	ϕ_1 (degrees)	Fig. 5			-75°			-121°			-72°			+ 0°			-20°		
7	ϕ_2 (degrees)	Fig. 5			+87°			-84°			+30°			-73°			-22°		
8	$(L_0)E_i$ (dBA)	Fig. 2			60.7			87.0						60.7			87.0		
9	10 LOG $(N_i D_0 / S_i)$ (dB)	Fig. 3			7.9			-			-4.8								
10a	10 LOG (D_0 / D) (dBA)	Fig. 4			+4.9									-2.3					
10b	15 LOG (D_0 / D) (dBA)	Fig. 4																	
11a	10 LOG $(\psi_0(\phi_1, \phi_2) / \pi)$ (dBA)	Fig. 6			-0.5									-5.0					
11b	10 LOG $(\psi_{1/2}(\phi_1, \phi_2) / \pi)$ (dBA)	Fig. 7																	
12	ϕ_L (degrees)	Fig. 10																	
13	ϕ_R (degrees)	Fig. 10																	
14	δ_0 (metres)	Fig. 9																	
15	N_0	Eq. 18																	
16	Δ_B (dBA)	Appendix B																	
17	CONSTANT (dB)	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25
18	$L_{eq}(h)$ (dBA)	47.9	-	61.6	52.8	-	57.4	58.4	-	43.2	54.5	-	59.3	52.2	-	57.7	51.4	-	56.8
19	$L_{eq}(h)$ (dBA)				61.8			58.7			41.4			60.5			58.7		
20	Δ_1 (dBA)	Fig. 8															57.9		
21	$L_{eq}(h)$ (dBA)																		
22	$L_{eq}(h)$ (dBA)																		
23	ND/S (m/km)																		
24	$(L_{10} - L_{eq})$ (dB)	Fig. 15																	
25	$L_{10}(h)$ (dBA)																		
26	$L_{10}(h)$ (dBA)																		
27	$L_{10}(h)$ (dBA)																		

NAME Receptor #1 PM Peak
 DATE 1990 No-Build

PROJECT DESCRIPTION corner of Oliver & 1st Street

		A(U)			B(U)			C(I)			D(I)			E(J)			F(I)			
1	LANE NO./ROAD SEGMENT	high 50 north of Oliver			Ramp 50 north of Oliver			high 50 south of Oliver			Oliver WB west of 1st			Oliver WB east of 1st			Oliver EB east of 1st			
2	VEHICLE CLAS.	A	MT	HT	A	MT	HT	A	MT	HT	A	MT	HT	A	MT	HT	A	MT	HT	
3.	N(vph)	600	-	28	533	-	22	699	-	29	222	-	9	19	-	1	280	-	12	
4	S(km/h)	40.3		40.3	40.3		40.3	40.3		40.3	45.2		45.2	45.2		45.2	45.2		45.2	
5.	D(m)	39.3m			25.7m			30.5m			11.3m			9.6m			5.2m			
6.	ϕ_1 (degrees)	Fig. 5			-17°			-19°			-67°			-67°			-34°			
7.	ϕ_2 (degrees)	Fig. 5			+47°			+56°			+6°			+61°			+69°			
8.	$(L_0)E$, (dBA)	Fig. 2						58.8	-	87.0	60.7	-	87.0				60.7	-	87.0	
9	10 LOG $(N/D_0/S_1)$ (dB)	Fig. 3						24.2	-	10.3	18.7	-	4.8				19.7	-	6.0	
10a.	10 LOG (D_0/D) (dBA)	Fig. 4						-3.1									-0.1			
10b.	15 LOG (D_0/D) (dBA)	Fig. 4																		
11a.	10 LOG $(\psi_0(\phi_1, \phi_2)/\pi)$ (dBA)	Fig. 6						-5.5			-7.3						-1.2			
11b.	10 LOG $(\psi_{1/2}(\phi_1, \phi_2)/\pi)$ (dBA)	Fig. 7																		
12	ϕ_L (degrees)	Fig. 10									$R_1 = 41m$									
13	ϕ_R (degrees)	Fig. 10									$R_2 = 32.8m$									
14	Δ_0 (metres)	Fig. 9																		
15	N_0	Eq. 18																		
16	Δ_B (dBA)	Appendix B									-20		-20							
17	CONSTANT (dB)		-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	
18	$L_{eq}(h)$ (dBA)		49.0	-	54.5	50.6	-	60.0	49.4	-	63.7	42.1	-	54.5	44.9	-	50.7	54.1	60.7	
19	$L_{eq}(h)$ (dBA)		55.6			57.1			63.9			54.7			51.7			60.9		
20	Δ_1 (dBA)	Fig. 8																		
21	$L_{eq}(h)$ (dBA)																			
22	$L_{eq}(h)$ (dBA)																			
23	ND/S (m/km)																			
24	$(L_{10} - L_{eq})$, (dB)	Fig. 15																		
25	$L_{10}(h)$ (dBA)																			
26	$L_{10}(h)$ (dBA)																			
27	$L_{10}(h)$ (dBA)																			

Noise Prediction Worksheet

$aeq = 59.4$ dBA

PROJECT DESCRIPTION Oliver Street, west of Purchase St
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Noise Prediction Worksheet

PROJECT DESCRIPTION _____

Noise Prediction Worksheet

$$x_{\text{eq}} = 72.2 \text{ dB}$$

NAME Receptor #1 TriPeak
 DATE 1990 Build

PROJECT DESCRIPTION corner of Oliver and Oak Streets

1	LANE NO./ROAD SEGMENT	A(U)			C(U)			D(I)			E(I)								
		A	MT	HT	A	MT	HT	A	MT	HT	A	MT	HT	A	MT	HT	A	MT	HT
2	VEHICLE CLAS																		
3	N(vph)	245	-	10	274	-	11	19	-	1	9	-	1						
4	S(km/h)	40.3	-	40.3	40.3	-	40.3	45.2	-	45.2	45.2	-	45.2						
5	D(m)	39.3 m			30.5 m			11.3 m			5.2 m								
6	ϕ_1 (degrees)	Fig. 5			-17°			+67°			-91°								
7	ϕ_2 (degrees)	Fig. 5			+47°			+81°			+59°								
8	$(L_o)E_i$ (dBA)	Fig. 2						80.7			80.7								
9	10 LOG $(N_i D_o / S_i)$ (dB)	Fig. 3						80			4.8								
10a	10 LOG (D_o / D) (dBA)	Fig. 4									-0.1								
10b	15 LOG (D_o / D) (dBA)	Fig. 4																	
11a	10 LOG $(\psi_b(\phi_1, \phi_2)/\pi)$ (dBA)	Fig. 6						-7.3			-1.2								
11b	10 LOG $(\psi_{1/2}(\phi_1, \phi_2)/\pi)$ (dBA)	Fig. 7																	
12	ϕ_L (degrees)	Fig. 10						$R_n = 41m$											
13	ϕ_R (degrees)	Fig. 10						$R_R = 82.8m$											
14	δ_o (metres)	Fig. 9																	
15	N_o	Eq. 18																	
16	Δ_B (dBA)	Appendix B																	
17	CONSTANT (dB)	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25
18	$L_{eq}(h)$ (dBA)	44.7	-	50.0	45.3	-	50.0	31.4	-	44.9	39.2	-	55.9						
19	$L_{eq}(h)$ (dBA)																		
20	Δ_s (dBA)	Fig. 8			51.1			51.7			45.1			56.0					
21	$L_{eq}(h)$ (dBA)																		
22	$L_{eq}(h)$ (dBA)																		
23	ND/S (m/km)																		
24	$(L_{10} - L_{eq})_i$ (dB)	Fig. 15																	
25	$L_{10}(h)$ (dBA)																		
26	$L_{10}(h)$ (dBA)																		
27	$L_{10}(h)$ (dBA)																		

Noise Prediction Worksheet

209-585

NAME Receptor #2 PM Peak
 DATE 1990 Build 1 - with Artery

PROJECT DESCRIPTION Over Sheet west of Purchase Street
1st 2

		B(U)			C(U)			D(U)			E(U)			F(U)			G(U)			
1.	LANE NO./ROAD SEGMENT	Cluster SB near 1st roundabout			Pavement SB near 2nd roundabout			Pavement SB South of roundabout			On-Ramp SB to bridge			Artificial SB between 2nd & 3rd ramp			Intersecting SB at ramp exit 3rd ramp			
2	VEHICLE CLAS	A	MT	HT	A	MT	HT	A	MT	HT	A	MT	HT	A	MT	HT	A	MT	HT	
3.	N(vph)	9	-	1	2480	-	112	2690	-	12	1061	-	44	5003	-	229	4336	-	21	
4	S(km/h)	45.2	-	45.2	45.2	-	45.2	45.2	-	45.2	41.3	-	41.3	41.3	-	41.3	41.3	-	41.3	
5.	D(m)	96m			16.9m			25.2m			31.3			49.1m			37.4m			
6.	ϕ_1 (degrees)	Fig 5	-3°			-72°			-6°			-63°			-58°			-42°		
7.	ϕ_2 (degrees)	Fig 5	+34°			+30°			+73°			-32°			-28°			-		
8.	$(L_0)E$, (dBA)	Fig. 2							10.7			-870								
9	10 LOG $(N/D_0/S)$, (dB)	Fig. 3							29.5			-157								
10a	10 LOG (D_0/D) , (dBA)	Fig 4							-23											
10b.	15 LOG (D_0/D) , (dBA)	Fig 4																		
11a.	10 LOG $(\psi_6(\phi_1, \phi_2)/\pi)$, (dBA)	Fig 6							-5.0											
11b.	10 LOG $(\psi_{1/2}(\phi_1, \phi_2)/\pi)$, (dBA)	Fig. 7																		
12	ϕ_L (degrees)	Fig 10																		
13	ϕ_R (degrees)	Fig 10																		
14	δ_0 (metres)	Fig 9																		
15	N_0	Eq 18																		
16	Δ_B (dBA)	Appendix B																		
17	CONSTANT (dB)		25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	
18	$L_{eq}(h)$, (dBA)		48.7	-	53.4	61.9	-	66.7	57.7	-	62.4	53.1	-	58.5	53.5	-	59.0	56.5	-	61.9
19	$L_{eq}(h)$, (dBA)		54.7			67.9			63.7			59.6			60.1			63.0		
20	Δ_1 , (dBA)	Fig 8																		
21	$L_{eq}(h)$, (dBA)																			
22	$L_{eq}(h)$, (dBA)																			
23	ND/S (m/km)																			
24	$(L_{10} - L_{eq})$, (dB)	Fig 15																		
25	$L_{10}(h)$, (dBA)																			
26	$L_{10}(h)$, (dBA)																			
27	$L_{10}(h)$, (dBA)																			

Noise Prediction Worksheet

NAME Receptor #2 PM Peak
 DATE 1990 Build 1 - with Artery

PROJECT DESCRIPTION Page 2

1.	LANE NO./ROAD SEGMENT	H(U)			I(U)			J(U)			K(U)								
		A	MT	HT	A	MT	HT	A	MT	HT	A	MT	HT	A	MT	HT	A	MT	HT
2	VEHICLE CLAS	5597	-	225	4547	-	89	4547	-	22	472	-	29						
3	N(vph)	403	-	403	403	-	403	403	-	403	403	-	403						
4	S(km/h)	403	-	403	403	-	403	403	-	403	403	-	403						
5	D(m)	40.2m			58.7m			56.3m			17.7m								
6	ϕ_1 (degrees)	Fig 5	+1°		-48°			-4°			-70°								
7	ϕ_2 (degrees)	Fig 5	+57°		+1°			+48°			-34°								
8	$(L_0)E$, (dBA)	Fig. 2																	
9	10 LOG $(N/D_0/S)$, (dB)	Fig. 3																	
10a	10 LOG (D_0/D) , (dBA)	Fig 4																	
10b	15 LOG (D_0/D) , (dBA)	Fig 4																	
11a	10 LOG $(\psi_6(\phi_1, \phi_2)/\pi)$, (dBA)	Fig 6																	
11b	10 LOG $(\psi_{1/2}(\phi_1, \phi_2)/\pi)$, (dBA)	Fig 7																	
12	ϕ_L (degrees)	Fig 10																	
13	ϕ_R (degrees)	Fig 10																	
14	δ_0 (metres)	Fig 9																	
15	N_0	Eq 18																	
16	Δ_B (dBA)	Appendix B																	
17	CONSTANT (dB)		-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25
18	$L_{eq}(h)$, (dBA)		57.4	-	62.9	54.5	-	59.9	55.7	-	61.1	49.4	-	54.8					
19	$L_{eq}(h)$, (dBA)		64.0			62.0			62.2			55.9							
20	Δ_1 (dBA)	Fig 8																	
21	$L_{eq}(h)$, (dBA)																		
22	$L_{eq}(h)$, (dBA)																		
23	ND/S (m/km)																		
24	$(L_{10} - L_{eq})$, (dB)	Fig 15																	
25	$L_{10}(h)$, (dBA)																		
26	$L_{10}(h)$, (dBA)																		
27	$L_{10}(h)$, (dBA)																		

Noise Prediction Worksheet

55.9 = 72.7 dBA

NAME Receptor #2 PM Peak
 DATE 1990-Build 2 - Central Artery Express

PROJECT DESCRIPTION Glenn St. east of Purchase St Page 1 of 2

1.	LANE NO./ROAD SEGMENT	S(U)			C(U)			D(U)			M(U)			L(I)			N(U)		
		A	MT	HT	A	MT	HT	A	MT	HT	A	MT	HT	A	MT	HT	A	MT	HT
3.	N(vph)	60	-	3	346	-	144	328	-	137	580	-	24	240	-	10	2242	-	23
4.	S(km/h)	45.2	-	45.2	45.2	-	45.2	45.2	-	45.2	40.3	-	40.3	45.2	-	45.2	41.4	-	41.4
5.	D(m)	16 m			16.4 m			25.0 m			27.3 m			7.2 m			70.7 m		
6.	ϕ_1 (degrees)	Fig. 5			-10°			-72°			-0°			+24°			-31°		
7.	ϕ_2 (degrees)	Fig. 5			-24°			-30°			+73°			+62°			+13°		
8.	$(L_0)E_i$ (dBA)	Fig. 2												20.7		97.0			
9.	10 LOG $(N, D_0/S_i)$ (dB)	Fig. 3												15.0	-	1.2			
10a.	10 LOG (D_0/D) (dBA)	Fig. 4																	
10b.	15 LOG (D_0/D) (dBA)	Fig. 4																	
11a.	10 LOG $(\psi_0, \phi_1, \phi_2)/\pi$ (dBA)	Fig. 6												-1.4					
11b.	10 LOG $(\psi_{1/2}, \phi_1, \phi_2)/\pi$ (dBA)	Fig. 7												Rn = 16.1 m					
12.	ϕ_L (degrees)	Fig. 10												Rf = 70.7 m					
13.	ϕ_R (degrees)	Fig. 10																	
14.	δ_0 (metres)	Fig. 9																	
15.	N_0	Eq. 18																	
16.	Δ_B (dBA)	Appendix B												-30		-30			
17.	CONSTANT (dB)	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25
18.	$L_{eq}(h)$ (dBA)	49.7	-	55.2	43.3	-	48.0	58.7	-	63.5	47.7	-	53.1	48.3	-	50.8	50.6	-	55.8
19.	$L_{eq}(h)$ (dBA)	56.3			62.3			64.7			54.2			61.0			56.9		
20.	Δ_i (dBA)	Fig. 8																	
21.	$L_{eq}(h)$ (dBA)																		
22.	$L_{eq}(h)$ (dBA)																		
23.	ND/S (m/km)																		
24.	$(L_{10} - L_{eq})$ (dB)	Fig. 15																	
25.	$L_{10}(h)$ (dBA)																		
26.	$L_{10}(h)$ (dBA)																		
27.	$L_{10}(h)$ (dBA)																		

Noise Prediction Worksheet

NAME Receptor #2 PM Peak
 DATE 1990-Build 2 - Central Artery Express

PROJECT DESCRIPTION Glenn St. east of Purchase St Page 2 of 2

1.	LANE NO./ROAD SEGMENT	O(U)			P(U)														
		A	MT	HT	A	MT	HT	A	MT	HT	A	MT	HT	A	MT	HT	A	MT	HT
3.	N(vph)	289	-	121	2505	-	104												
4.	S(km/h)	41.9	-	41.9	40.3	-	40.3												
5.	D(m)	72.3 m			16.8 m														
6.	ϕ_1 (degrees)	Fig. 5			-12°														
7.	ϕ_2 (degrees)	Fig. 5			+35°														
8.	$(L_0)E_i$ (dBA)	Fig. 2																	
9.	10 LOG $(N, D_0/S_i)$ (dB)	Fig. 3																	
10a.	10 LOG (D_0/D) (dBA)	Fig. 4																	
10b.	15 LOG (D_0/D) (dBA)	Fig. 4																	
11a.	10 LOG $(\psi_0, \phi_1, \phi_2)/\pi$ (dBA)	Fig. 6																	
11b.	10 LOG $(\psi_{1/2}, \phi_1, \phi_2)/\pi$ (dBA)	Fig. 7																	
12.	ϕ_L (degrees)	Fig. 10																	
13.	ϕ_R (degrees)	Fig. 10																	
14.	δ_0 (metres)	Fig. 9																	
15.	N_0	Eq. 18																	
16.	Δ_B (dBA)	Appendix B																	
17.	CONSTANT (dB)	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25
18.	$L_{eq}(h)$ (dBA)	51.9	-	57.1	50.0	-	55.4												
19.	$L_{eq}(h)$ (dBA)	58.3			56.5														
20.	Δ_i (dBA)	Fig. 8																	
21.	$L_{eq}(h)$ (dBA)																		
22.	$L_{eq}(h)$ (dBA)																		
23.	ND/S (m/km)																		
24.	$(L_{10} - L_{eq})$ (dB)	Fig. 15																	
25.	$L_{10}(h)$ (dBA)																		
26.	$L_{10}(h)$ (dBA)																		
27.	$L_{10}(h)$ (dBA)																		

Noise Prediction Worksheet

$L_{eq} = 71.3$ dB

NAME Receptor #1 M Peak
 DATE 1990 - Guilds - Central Artery Express

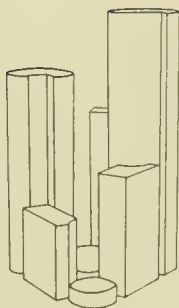
PROJECT DESCRIPTION curves of River and high streets

1	LANE NO / ROAD SEGMENT	A(U)			C(U)			D(I)			F(I)								
		A	MT	HT	A	MT	HT	A	MT	HT	A	MT	HT	A	MT	HT	A	MT	HT
2	VEHICLE CLAS.																		
3	N(vph)	149	-	8	278	-	12	19	-	1	60	-	3						
4	S(km/h)	40.3	-	40.3	40.3	-	40.3	45.2	-	45.2	45.2	-	45.2						
5	D(m)	29.3 m			30.5 m			11.3 m			15.2								
6	ϕ_1 (degrees) Fig. 5	-17°			-107°			+67°			-81°								
7	ϕ_2 (degrees) Fig. 5	+47°			-10°			-81°			+59°								
8	$(L_o)E_i$ (dBA) Fig. 2							80.7	-	87.0	80.7	-	87.0						
9	10 LOG $(N_o D_o / S_i)$ (dB) Fig. 3							8.0	-	-4.8	8.0	-	0						
10a	10 LOG (D_o / D) (dBA) Fig. 4										-0.1								
10b	15 LOG (D_o / D) (dBA) Fig. 4																		
11a	10 LOG $(\psi_b(\phi_1, \phi_2)/\pi)$ (dBA) Fig. 6							-7.3											
11b	10 LOG $(\psi_{1/2}(\phi_1, \phi_2)/\pi)$ (dBA) Fig. 7										-1.2								
12	ϕ_L (degrees) Fig. 10							$R_n = 41m$											
13	ϕ_R (degrees) Fig. 10							$R_r = 82.9m$											
14	δ_o (metres) Fig. 9																		
15	N_o Eq. 18																		
16	Δ_B (dBA) Appendix B							-30		-30									
17	CONSTANT (dB)	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25	-25
18	$L_{eq}(h)$ (dBA)	43.0	-	49.1	45.4	-	50.2	51.4	-	44.9	47.4	-	50.7						
19	$L_{eq}(h)$ (dBA)	50.2			52.0			45.1			50.9								
20	Δ_i (dBA) Fig. 8																		
21	$L_{eq}(h)$ (dBA)																		
22	$L_{eq}(h)$ (dBA)																		
23	ND/S (m/km)																		
24	$(L_{10} - L_{eq})$ (dB) Fig. 15																		
25	$L_{10}(h)$ (dBA)																		
26	$L_{10}(h)$ (dBA)																		
27	$L_{10}(h)$ (dBA)																		

Noise Prediction Worksheet

$L_{eq} = 50.9$ dBA

Shadow Analysis



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3. SHADOW ANALYSIS

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3. Shadow Analysis

Shadow diagrams have been compiled depicting increased shadows associated with the completed International Place project. The areas potentially effected by shadows of the complex are: 1) the downtown area north of High Street during morning hours, 2) areas adjacent to and including the expressway, north of the site, at midday, and 3) the expressway and waterfront areas north of the site during afternoon hours. The shadow studies were compiled in a series of working sessions with the BRA design review and environmental staffs beginning in January 1984. In the first iteration the studies addressed shadows cast by twin towers of 46 and 36 stories. Shadows for each season were studied as follows: summer shadow (June 22); for peak winter shadow (December 22); and for the spring and fall equinox cases. The first study indicated that new shadows in October would fall on the open area at the intersection of India and Milk Streets in front of and adjacent to the Grain Exchange building. A second study, with the north tower reduced from 36 to 35 stories, demonstrated that more sunlight would reach pedestrian walkways in that area at mid-morning for much of the month of October. The Chiofaro Company agreed to the one story reduction. Consequently, the shadow diagrams in the analysis for this report reflect the modified design of a 35 story north tower.

For each time of year, representative morning (10:00 AM), noon, and afternoon (2:00 PM) shadow patterns were calculated. In addition, a late afternoon (4:00 PM) shadow pattern for June 22 was determined. Shadow patterns for each analysis combination are presented in

Figures 3.1 through 3.13. The thirteen figures present the shadow profile for each scenario. The profile is shown by the dark outline in each figure. The diagrams also show, in gray, the location of net new shadows. The net new shadows are the better measure of shadow impact. They depict the areas in which new shadows fall on previously sunny locations. Those areas within the project shadow path that are left unshaded represent areas where the International Place shadows overlap existing shadows from other buildings. Building heights utilized to calculate the shadow lengths are as follows:

BUILDING HEIGHTS

North Tower:	459' 9"
Building element connected	
to North Tower:	161' 3"
South Tower:	600' 0"
West building element connected	
to South Tower:	263' 3"
East building element connected	
to South Tower:	365' 3"

During the summer, when people are frequently outdoors and potential impacts are most noticeable, effects will be minimal as new shadows impact only building facades and rooftops in the immediate area and the streets and sidewalks immediately adjacent to the proposed site. This is a direct result of the higher solar altitude angle experienced during the summer season. Figure 3.14 shows this by comparing the effect of solar altitude angle on shadow length at noontime for the summer, spring/fall, and winter analysis cases.

During the spring and fall equinox, shadows begin to reach further north of the site as the solar-altitude angle decreases. At the same time, the lateral angle, through which shadows sweep from morning to evening, decreases as demonstrated in Figure 3.15. The figure depicts the lateral sweep of the sun's path between the hours 8 AM and 4 PM by season. By winter solstice, shadow lengths reach a maximum and lateral angle sweep a minimum.

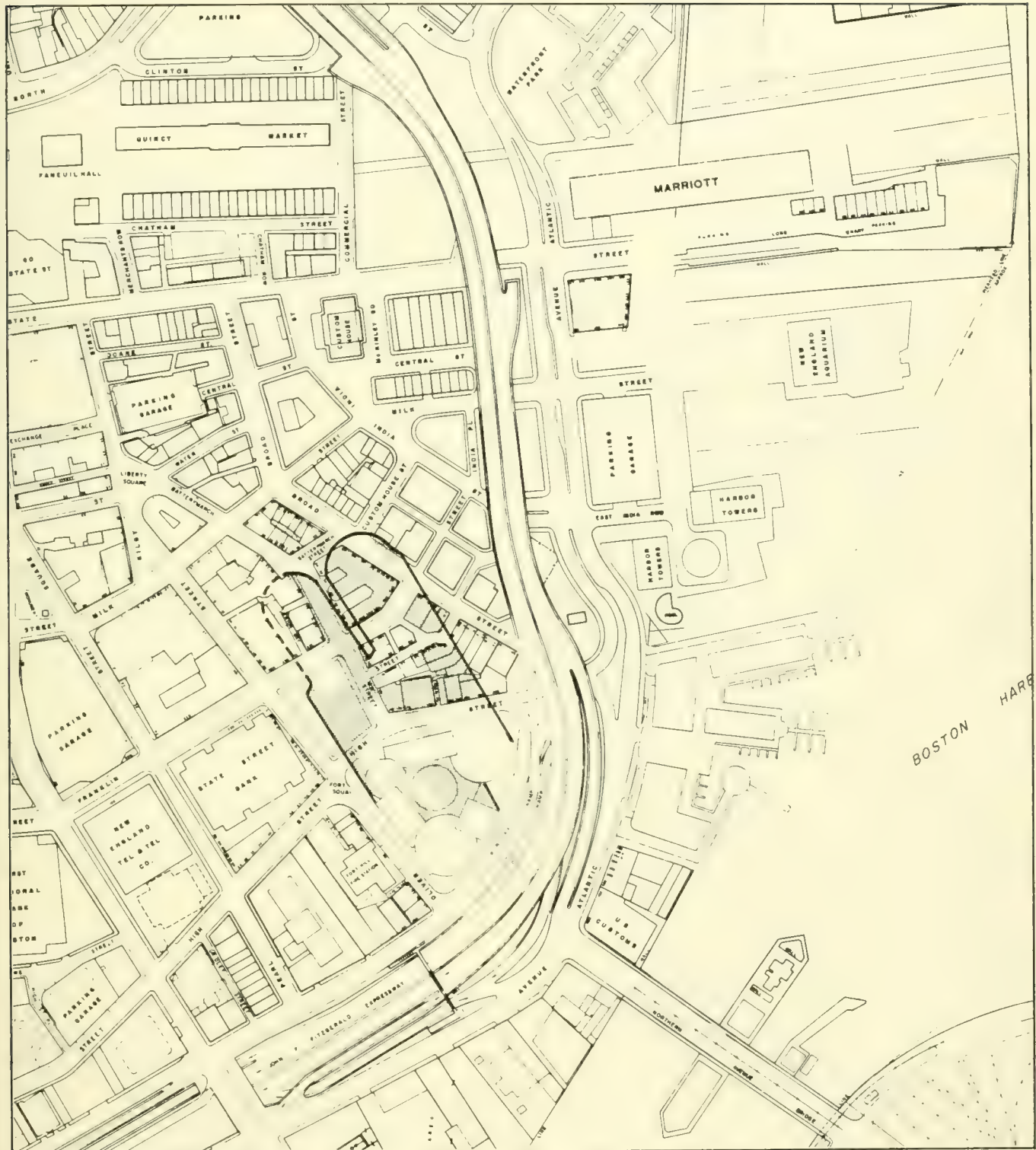
During morning hours of winter the International Place shadow path extends to the Quincy Market area. However, the project-related shadow is superimposed over the existing shadows, caused by other buildings, and no new shadows fall on previously sunny areas of the Quincy Market area. The shadow path of the complex will extend north of the site along Atlantic Avenue and the expressway, at noontime, casting some new shadows on these roadways. During winter afternoon hours the shadow path will extend across Long Wharf, resulting in a small amount of new shadow at waterfront locations. At no time do shadows from the project reach Waterfront Park.

As mentioned previously, a special analysis was performed for October 21 to measure the impact on areas around the Grain Exchange building. That analysis demonstrates that only the southern edge of the open area west of the Grain Exchange building will be under new shadows (from approximately 10:15 to 10:45). It also indicates that new shadows will sweep along the northern side of India Street to India Place for about one hour (10:30 - 11:30 AM) at that time of year.

In summary, Figures 3.1 through 3.13 demonstrate that new shadows of International Place fall primarily on streets adjacent to the project site, building facades and rooftops in the downtown area, the expressway, and a small

number of open areas and buildings along the waterfront. The analysis, also, indicates that many pedestrian areas within the project's shadow path (especially to the north and west of the site) are presently shaded by existing structures due to the character of urban street canyons in this part of Boston. Further, the project will not produce additional shadows in already sunny locations of special concern areas as Quincy Market and Waterfront Park. Overall, new shadows created by the project should not be perceived as significant by abutters or pedestrians in the area.

Figure 3.1 March 21/September 23, 10:00 AM



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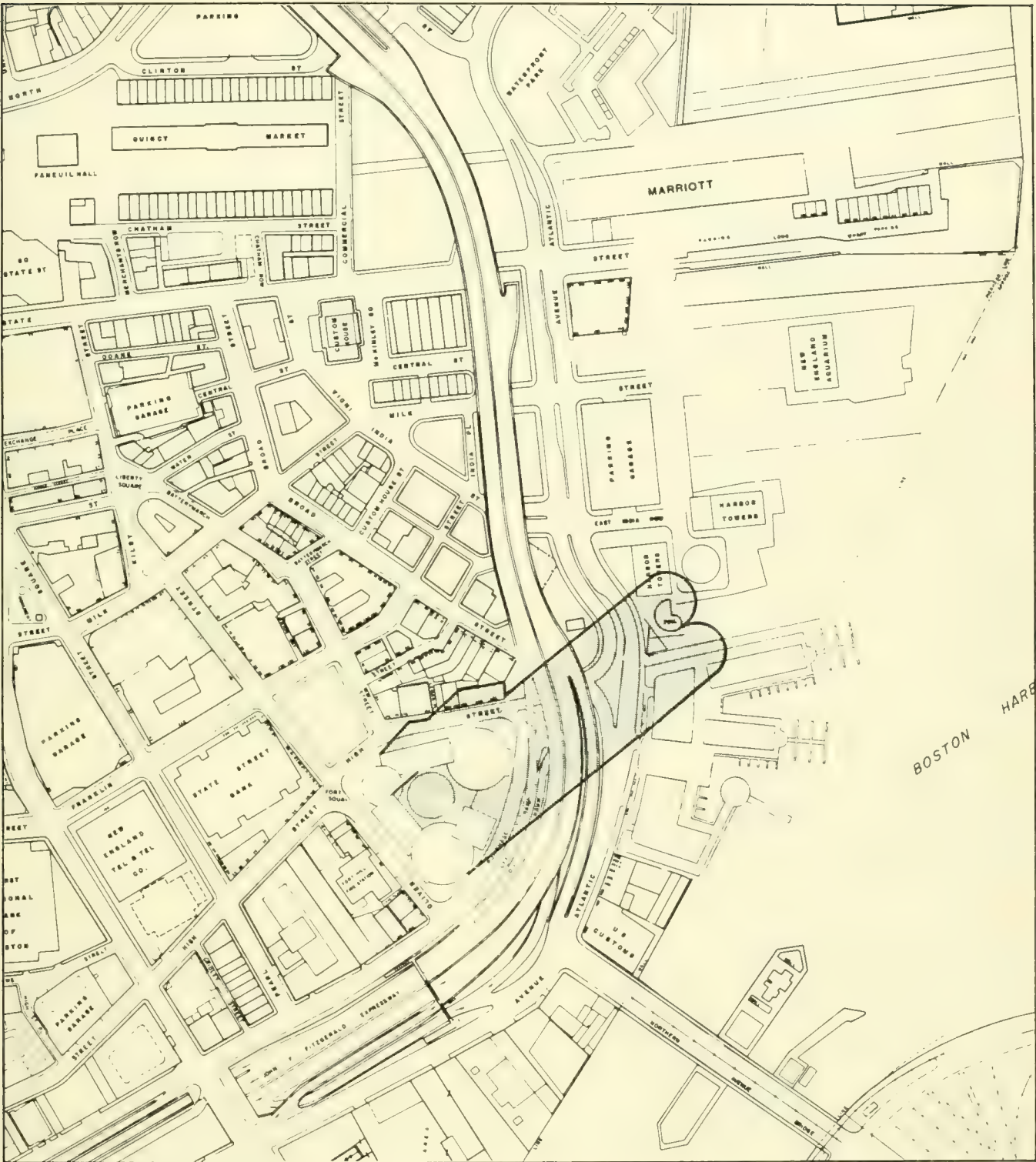
Figure 3.2 March 21/September 23, Noon



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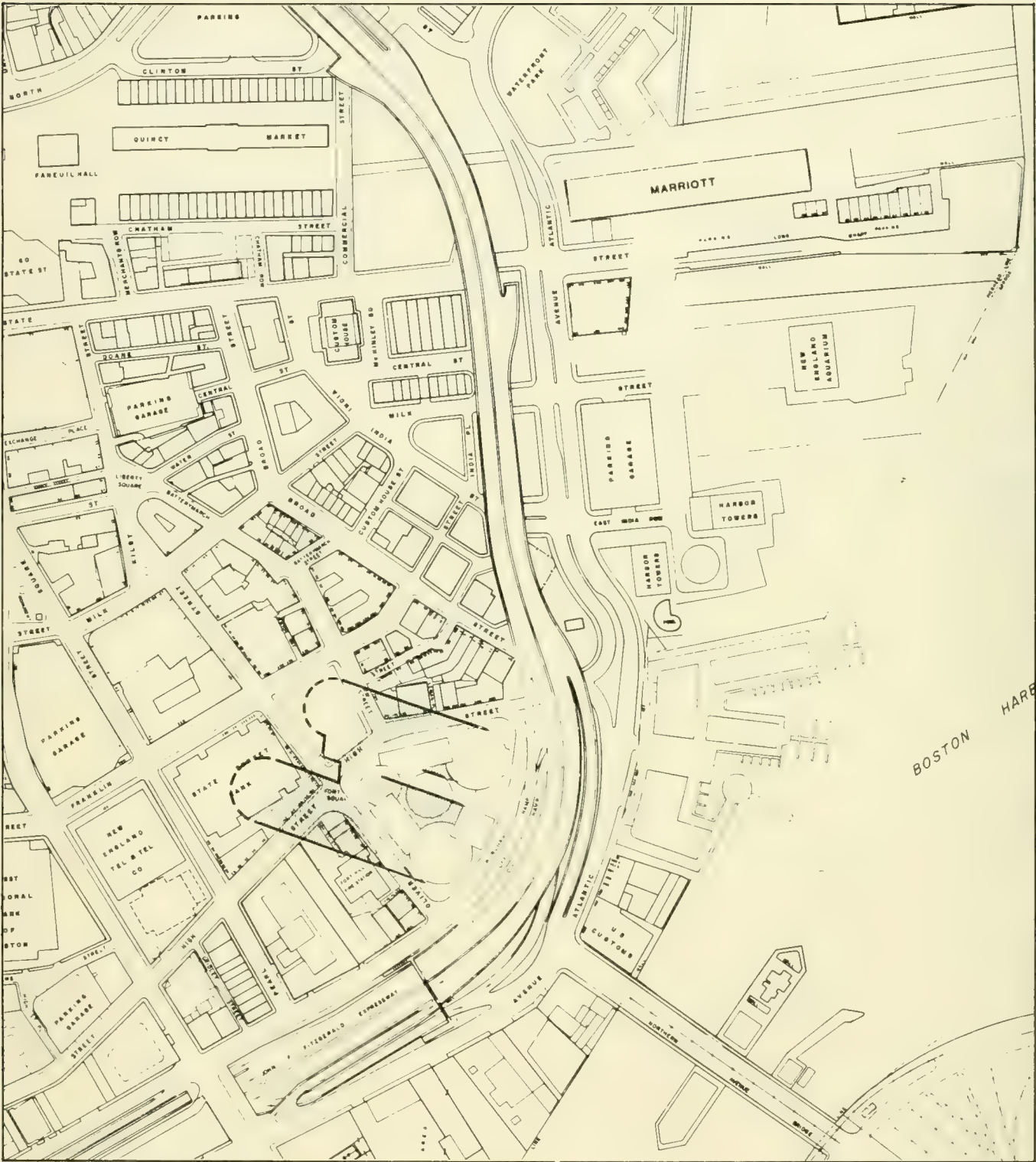
Figure 3.3 March 21/September 23, 2:00 PM



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HMM Associates
Concord, MA

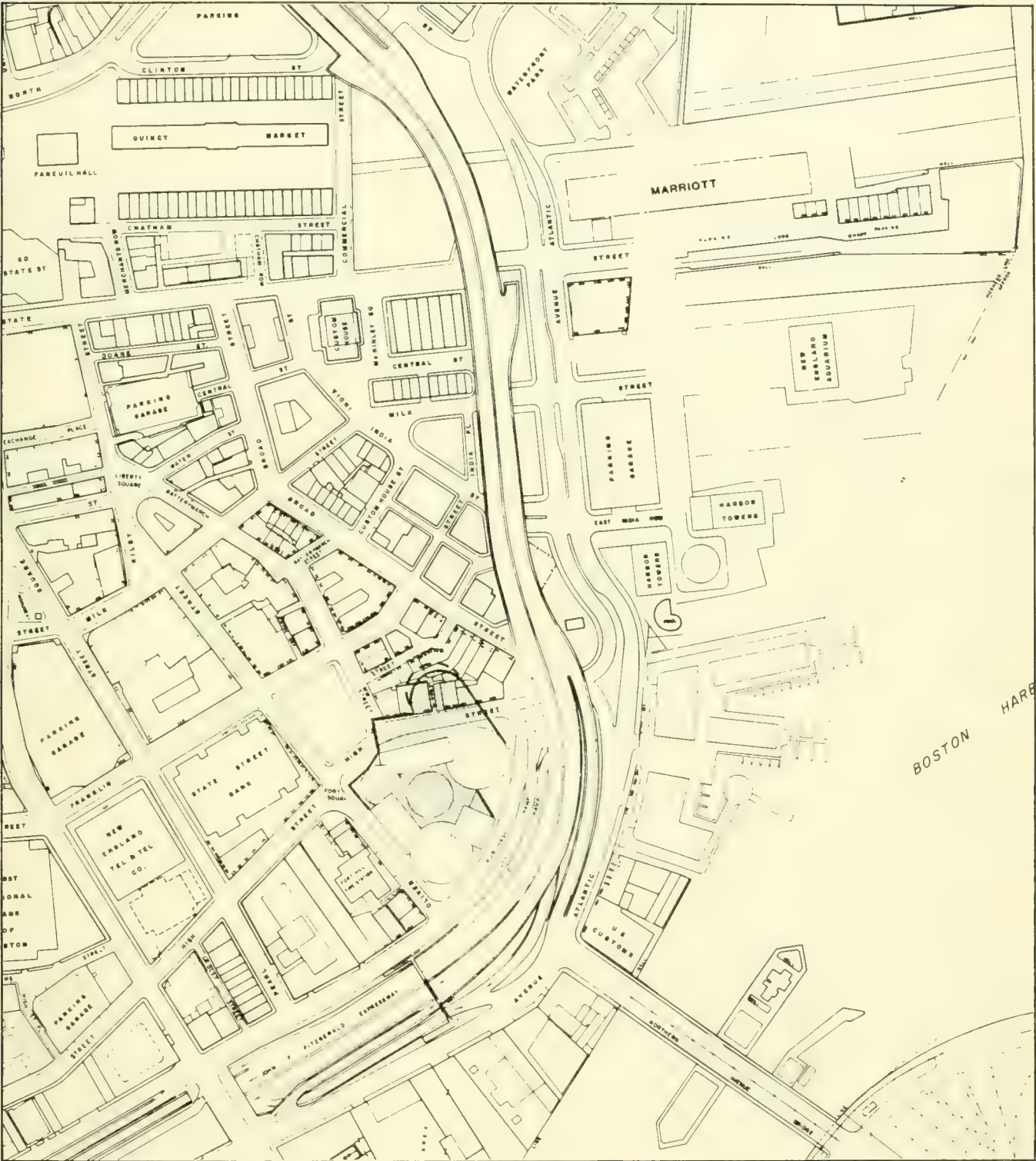
Figure 3.4 June 22, 10:00 AM



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Figure 3.5 June 22, Noon



International
Place
at Fort Hill

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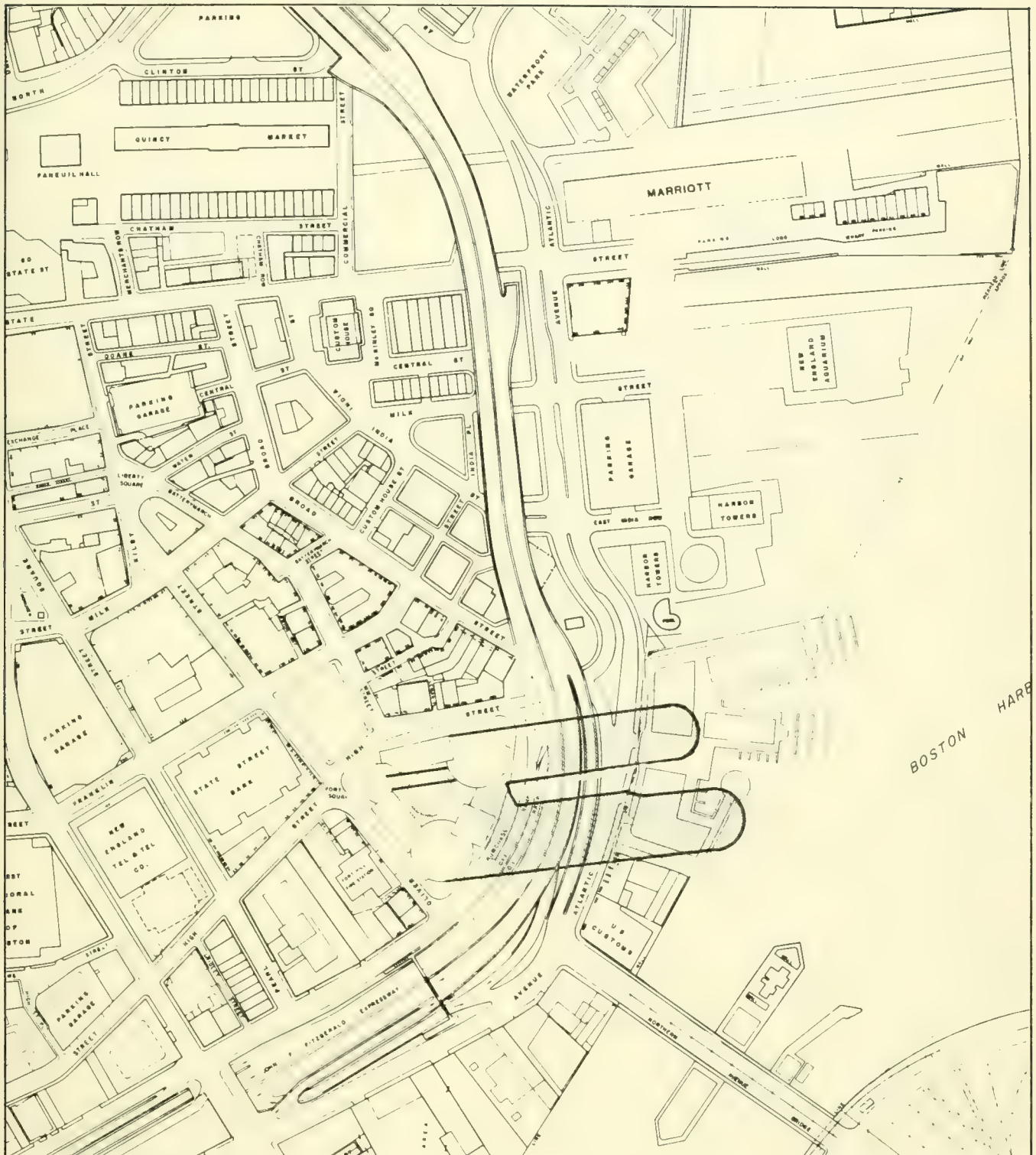
Figure 3.6 June 22, 2:00 PM



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Figure 3.7 June 22, 4:00 PM

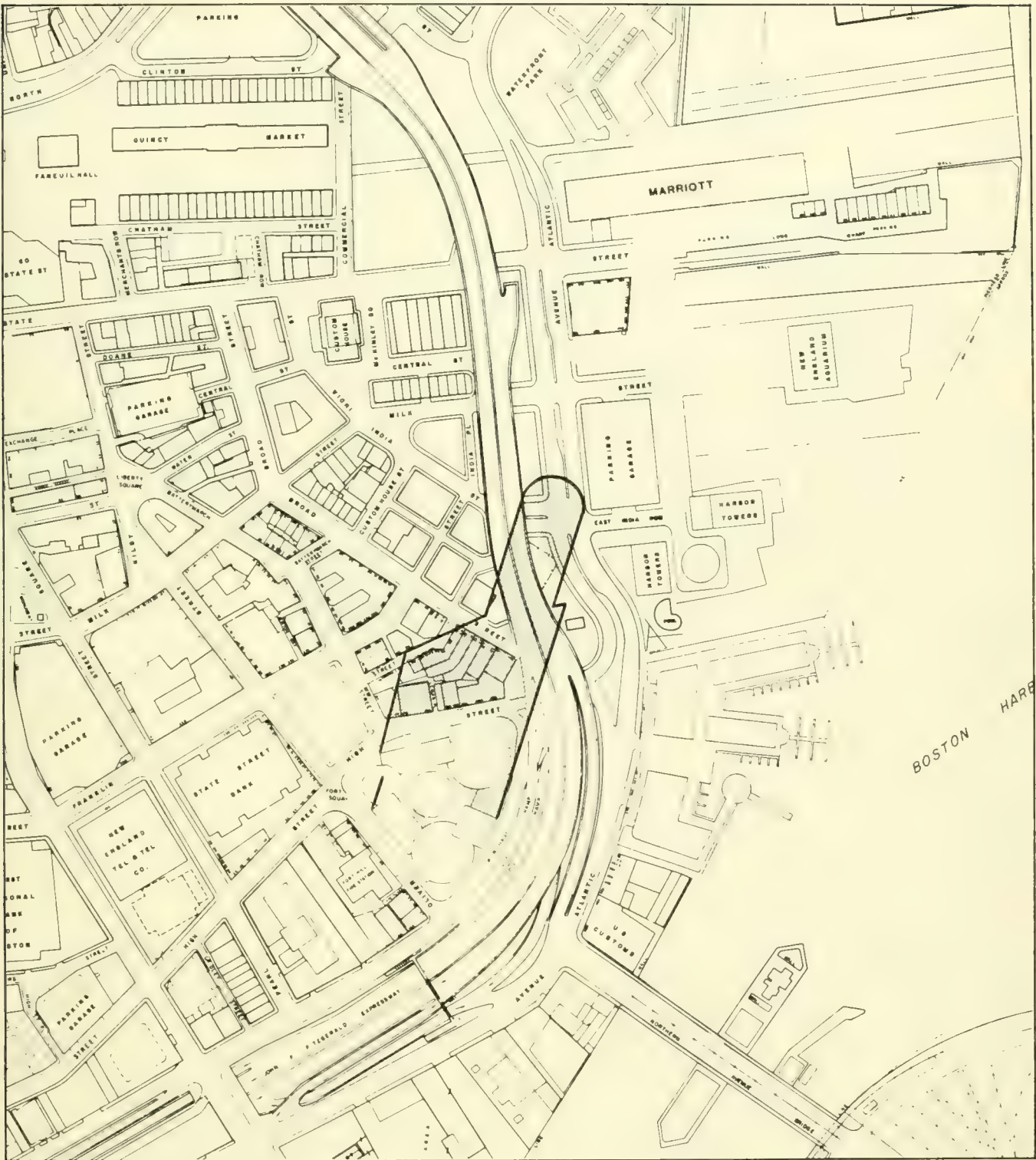


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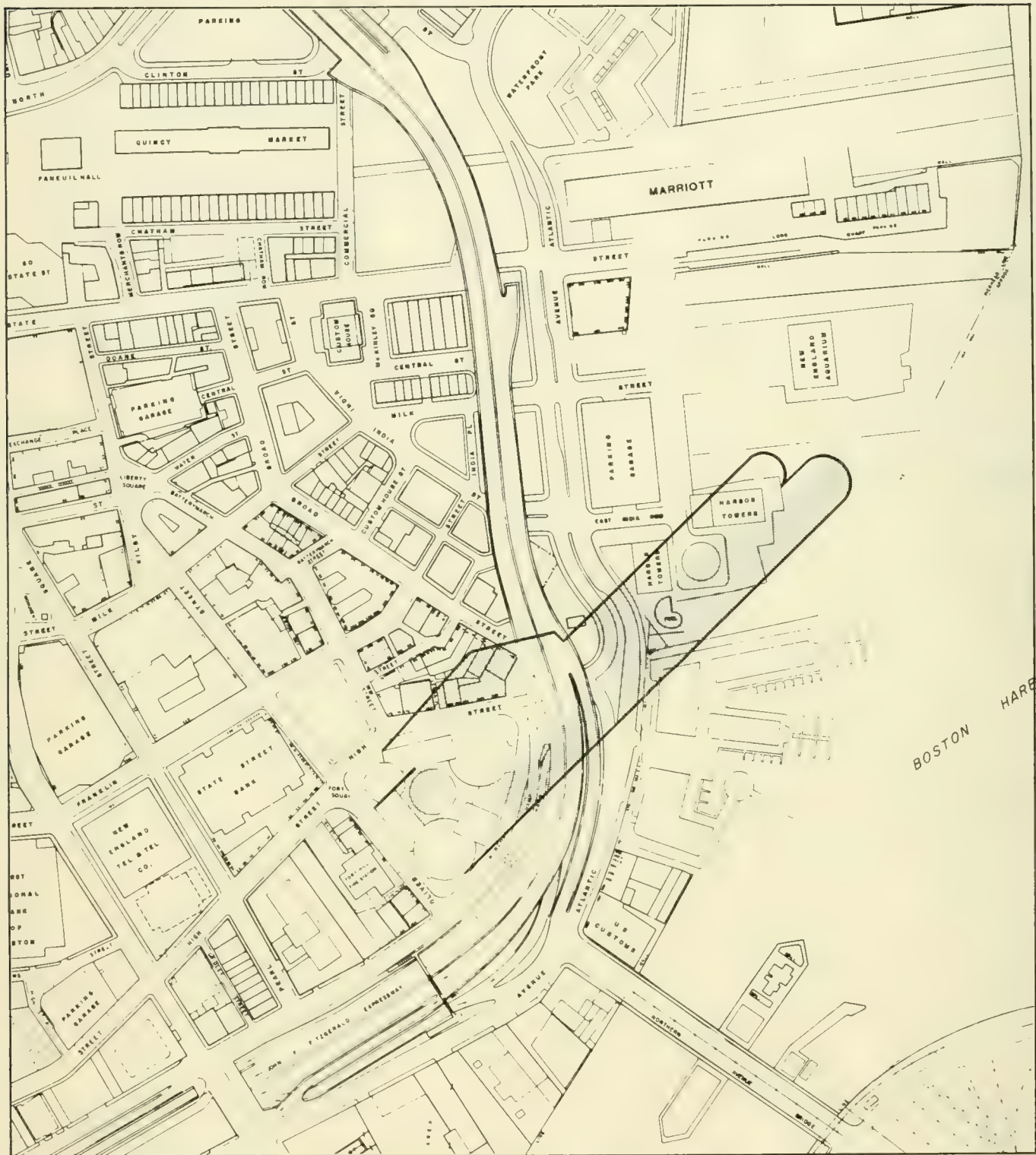
Figure 3.9 October 21, Noon



International
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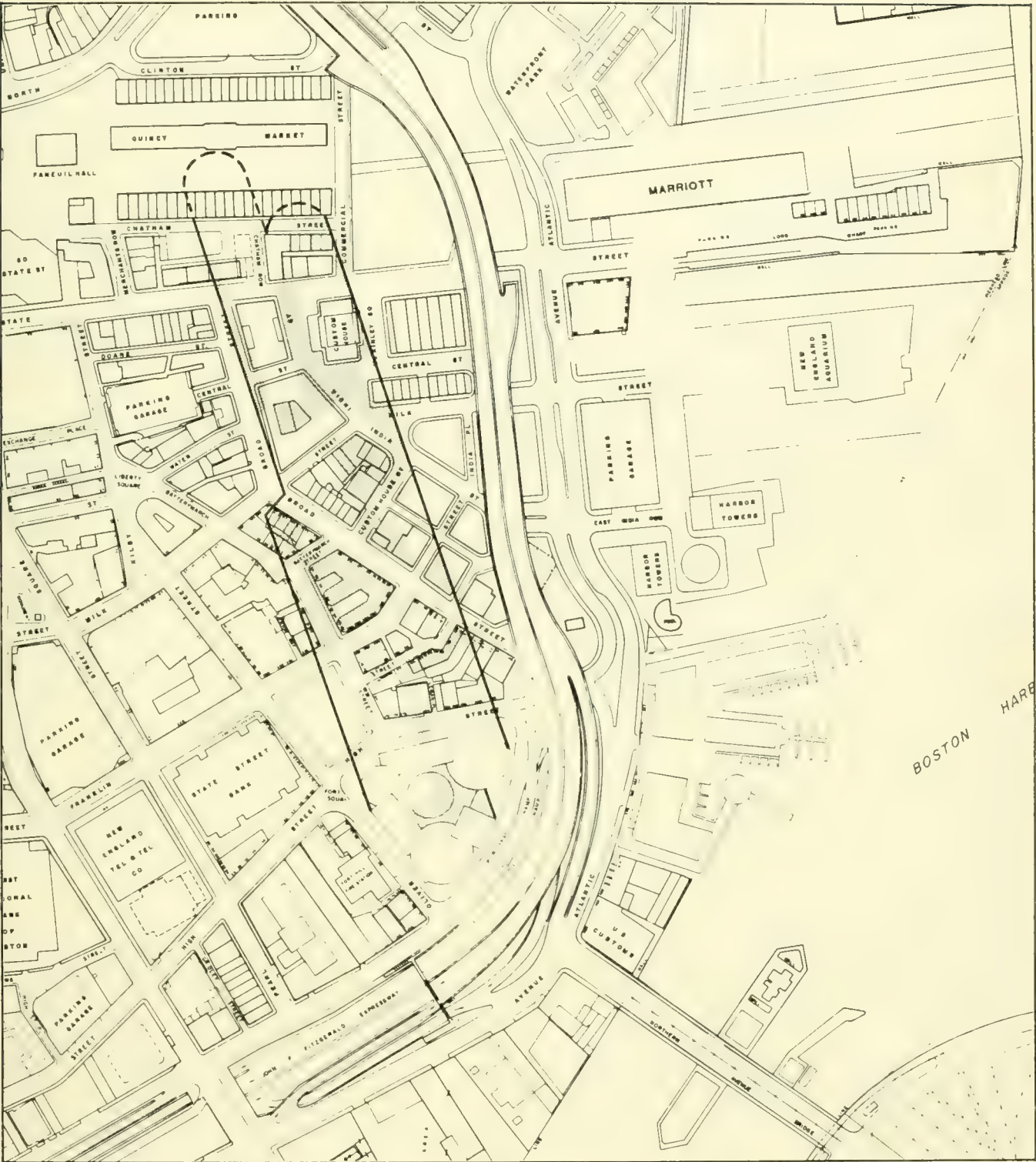
Figure 3.10 October 21, 2:00 PM



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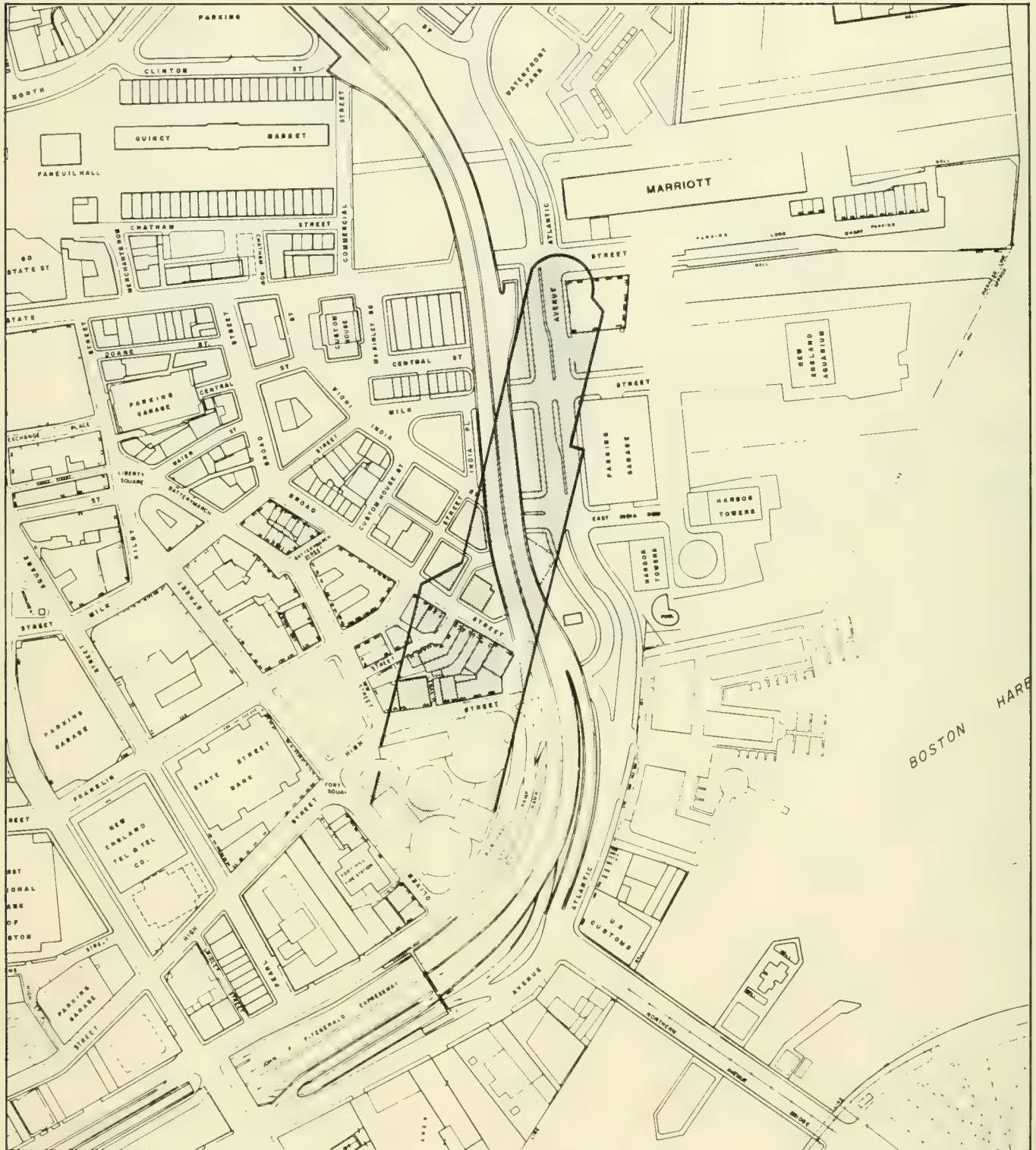
Figure 3.11 December 22, 10:00 AM



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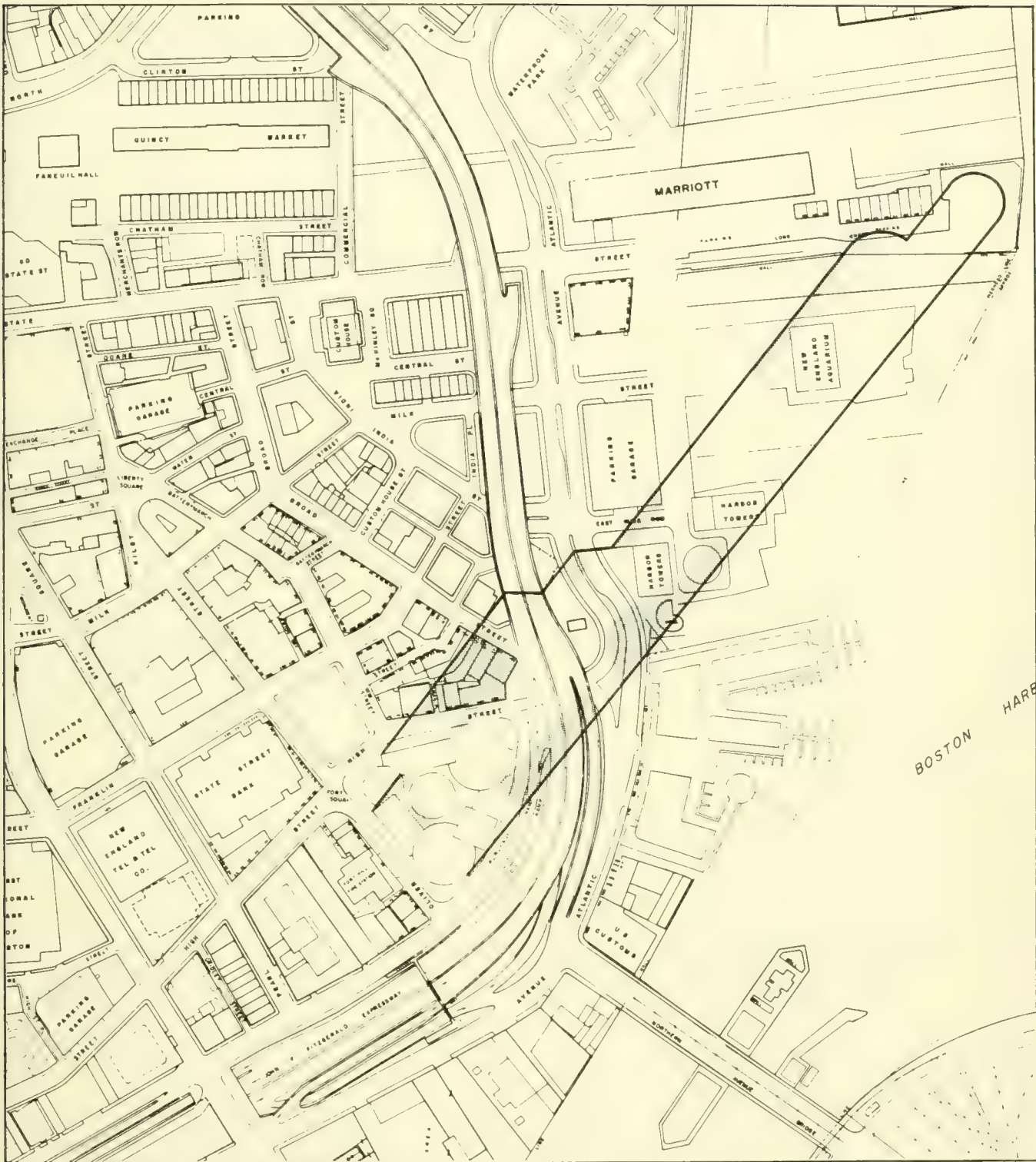
Figure 3.12 December 22, Noon



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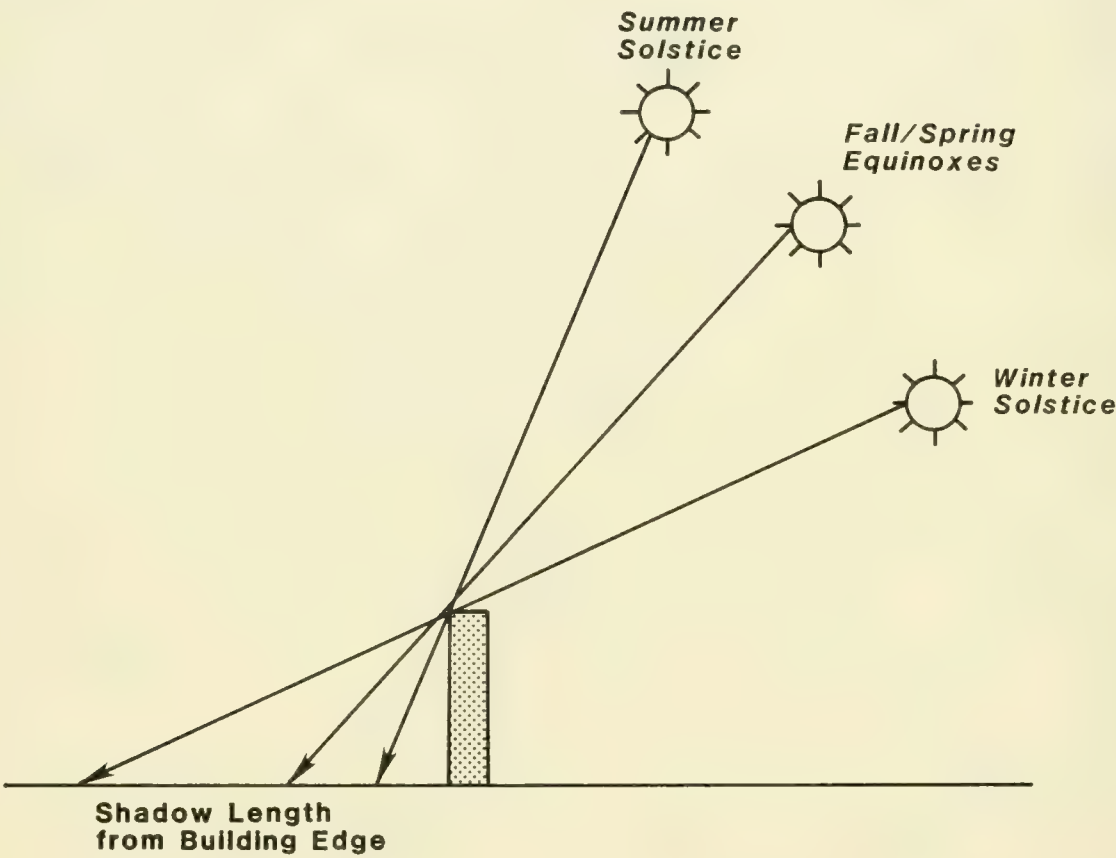
Figure 3.13 December 22, 2:00 PM



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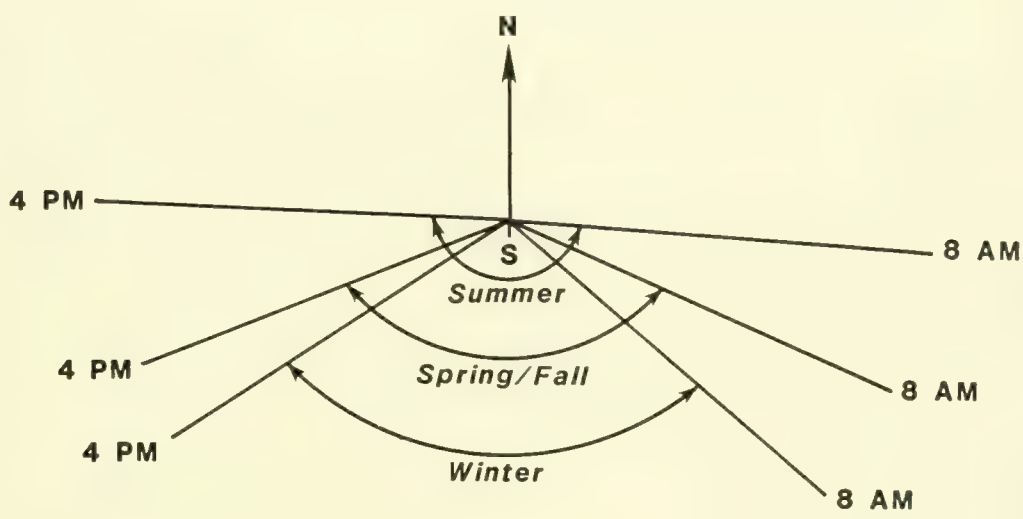
Figure 3.14 Noontime Solar Altitude Angles



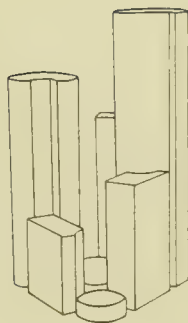
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Figure 3.15 Lateral Sweep of Sun's Path by Season (8 AM - 4 PM)



Transportation



The following Transportation report supplants the initial analysis submitted to the Boston Redevelopment Authority as part of the May, 1984 EIR. It is the same report submitted to the Massachusetts Secretary of Environmental Affairs office as the Final EIR in compliance with G.L., Chapter 30, Section 62-62H and the regulations implementing the Massachusetts Environmental Protection Agency (MEPA). As such, it incorporates the comments received from public agencies and private organizations, including those from the BRA. Further responses to BRA comments are contained in the Comments and Responses section of this Report.

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DESCRIPTION OF THE ENVIRONMENT

TRANSPORTATION

A. INTRODUCTION

The Boston downtown area including the financial district, waterfront, and Fort Point Channel area has been experiencing a considerable amount of interest as a vital commercial area for the City of Boston. Numerous developments have recently been completed or are underway in either planning or construction. Included is the reuse of Commonwealth Pier as BOSCOM - a trade center for the computer industry; One Financial Center at Dewey Square; Exchange Place 53 State Street, Marketplace Center, all new hotel development, Rowes Wharf and Building 114. In addition, there are several smaller projects underway to renovate or to improve the utilization of various existing buildings in the area. International Place continues this economic growth process in downtown.

The design year for International Place is 1990 and in establishing 1990 Base or No Build conditions for the traffic analysis, all development and transportation improvement projects currently anticipated to be in place by 1990 were considered.

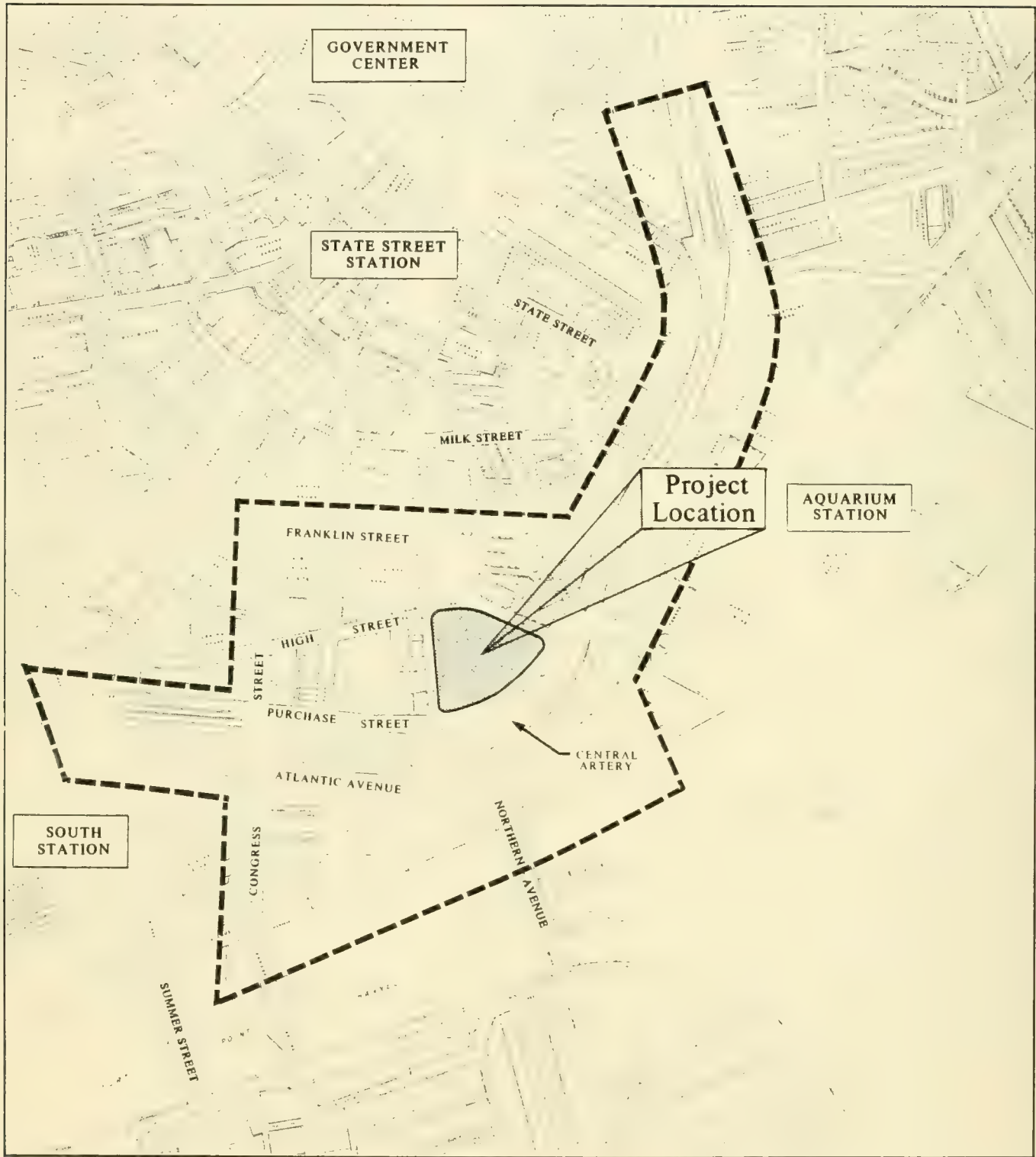
The transportation analysis study process can generally be divided into three distinct steps. Each step builds on the previous step in developing a comprehensive study of all traffic impacts stemming from the proposed project. These steps are described below:

- 1) Description of the Environment - Existing transportation conditions in the study area were defined including peak hour traffic flow patterns, traffic volumes, roadway geometrics, travel behavior characteristics, transit system line performance measures, and the existing parking system supply demand characteristics. The description provides a good starting point on which to base project impact analysis.
- 2) Probable Impacts of the Project - This second step involves forecasting transportation demands generated by the proposed development along with forecasts of traffic generated from other anticipated land development in the study area. A detailed comparison between the forecasted travel demands and future roadway and transit system capacities was conducted to identify potential problem areas with the transportation system serving the study area.
- 3) Measures to Mitigate Environmental Impact - This final step in the study process was conducted to identify potential solutions and to provide recommendations on problematic transportation impacts created by the proposed development. These mitigating measures may include modifying the project scale, developing alternative access plans, roadway improvements, promotion of techniques to increase vehicular occupancy (ridesharing, vanpools, etc.); and the implementation of other demand modification techniques such as staggering work hours and/or the use of compressed work weeks.

Discussions were held with MEPA staff to clarify the scope of the project and the traffic analysis area was defined. The transportation study encompassed a relatively large portion of the Financial District/South Station area as shown in Figure 1. The study area boundaries essentially included the Fort Point Channel on the east, Franklin Street on the west, North Street on the north including Dock Square and Dewey Square to the south. In general, the street system within this area forms a one-way grid pattern which facilitates traffic circulation and flow. In addition, the Central Artery passes through the middle of the study area with off-ramps located at High Street, Purchase Street, and Atlantic and Northern Avenues. On-ramps are currently located off Purchase Street, Congress Street and Atlantic and Northern Avenues.

Public transportation in this area is also well developed and highly utilized. The MBTA's Red, Orange and Blue Lines currently serve the study area with subway stations at South Station (Red), State Street (Orange), and Aquarium (Blue). The Green Line also serves the area to a limited extent with Stations at Park Street and Government Center. South Station also accommodates extensive commuter rail service between downtown and the southern and western suburbs. In addition, numerous MBTA express and local bus routes terminate at South Station, and the intersection of Franklin and Federal Streets. The Trailways Terminal which is approximately two blocks south of the project site, provides intercity private bus carrier service.

Figure 1 -Transportation Study Area



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B. EXISTING TRANSPORTATION SYSTEM

The existing transportation system within the study area is highly developed consisting of regional highways, an arterial street system, several bus routes, heavy rail transit service, commuter/intercity rail service, as well as a commuter boat system. The following paragraphs briefly describe characteristics of the system.

1. Street System

The street system in the Fort Hill/South Station area consists of both local and arterial streets and Limited Access Highways. The regional highway system serving the City and the overall area include:

- The Mass Turnpike Extension linking the Downtown Boston with the western suburbs;
- Storrow Drive interchanging with the local street system at several points providing regional service to the west and north;
- The Southeast Expressway providing a link to the south shore;
- Interstate Route 93 and U.S. Route 1 connecting downtown with the northern suburbs; and
- The Central Artery connecting the northern and southern highways as well as the Callahan and Sumner Tunnels in downtown Boston.

These regional highways are four to eight lane limited access facilities connecting downtown Boston with the metropolitan suburbs and points beyond.

The major arterials which serve the site include Purchase Street, the Surface Artery, Atlantic Avenue and High Street. These roadways consist of 2 to 4 lane uni-directional facilities with varying curbside parking regulations. These major arterials make connections with the Central Artery via the following ramps:

On-Ramps

Northern Avenue @ Atlantic Avenue (northbound)

Atlantic Avenue @ Congress Street (northbound)

Congress Street @ Purchase Street (southbound)

South Street @ Surface Artery (northbound)

North Street @ Sumner Tunnel (southbound)

Purchase Street @ Surface Artery (southbound)

Off-Ramps

Northern Avenue/High Street/Atlantic Avenue (northbound)

High Street at Oliver Street (southbound)

Purchase Street at Summer Street (southbound)

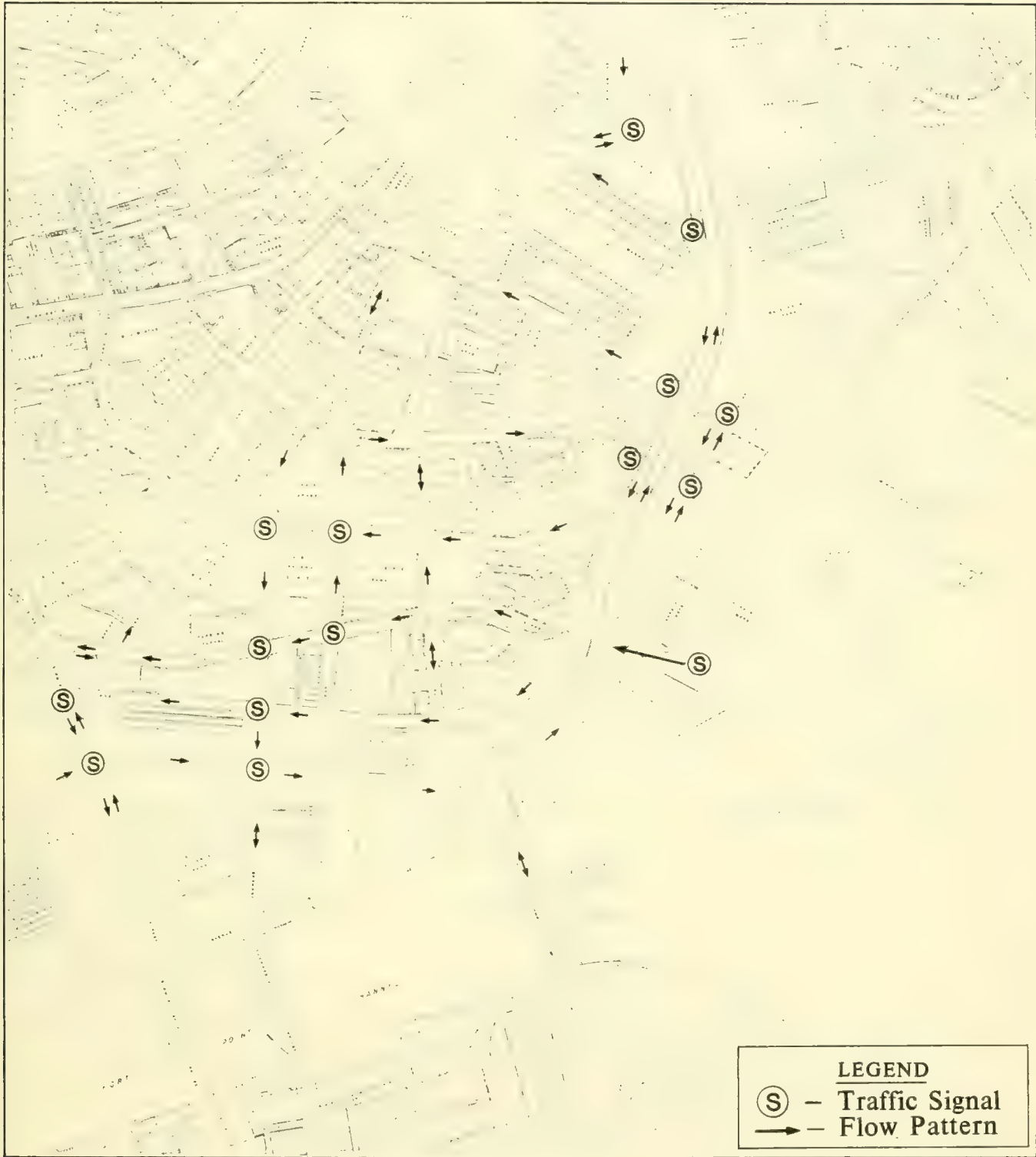
Beach Street at Surface Artery (southbound)

North Street at Blackstone Street (southbound)

Kneeland Street/Atlantic Avenue (northbound)

The local street system which is depicted in Figure 2 consists essentially of a one-way street circulation pattern. In essence, a grid type system is formed by the roadway network. Fifteen of the

Figure 2 - Existing Study Area Traffic Flow Patterns



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seventeen intersections which are to be analyzed are signalized, although the Dock Square signal currently operates on flash.

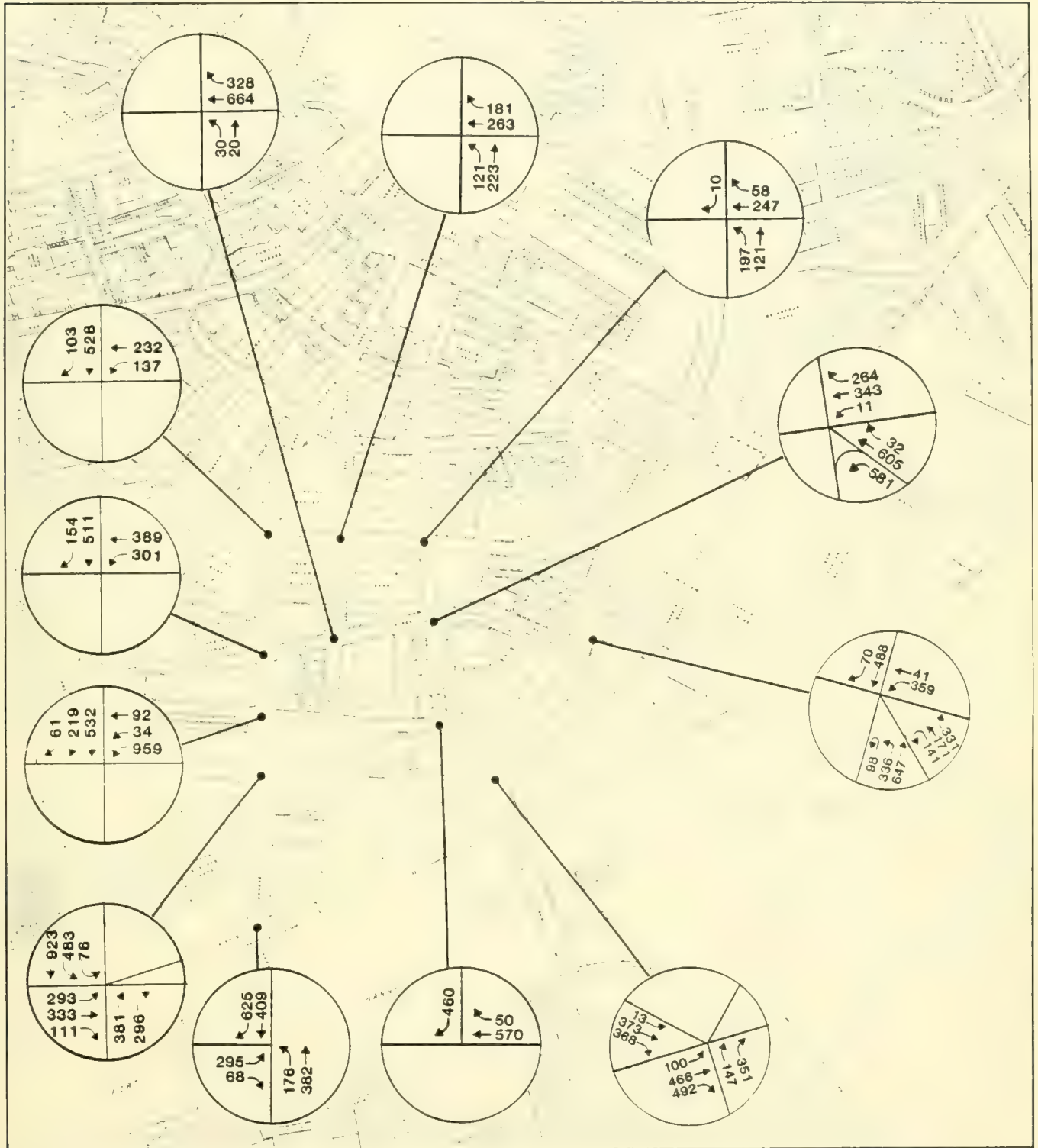
2. Existing Traffic Volumes

Existing AM peak hour PM peak hour traffic volume networks are illustrated in Figures 3 and 4. As discussed in detail in the Transportation Comments and Response Section of this FEIR, the existing AM and PM network was developed from actual count data for each of the seventeen locations. These data included both turning movement counts and mechanical recorder counts taken during the period of 1979 to 1984 by this consultant as well as other sources. The data is included in the appendix. Table 1 illustrates all count data reviewed and used in this analysis.

Also described in detail in the comment/response section is the general procedure used in developing existing flow networks which represented typical downtown conditions and also were reasonably balanced networks (i.e. within the range of daily traffic fluctuation). Observations in downtown indicate day to day traffic volume conditions can vary up to 35 percent of average week conditions.

Based on these observed counts and results from the 1982 Boston Cordon Count, the overall peak hours in downtown occur from 7:30 AM - 8:30 AM and 4:30 PM - 5:30 PM. Depending on location and daily fluctuation of traffic, the peak hour at individual locations may vary within a half hour of the overall network peak. With the exception of a few turning movements at various intersections, the observed PM peak hour volumes in the study are generally greater

Figure 3a- Existing AM Network



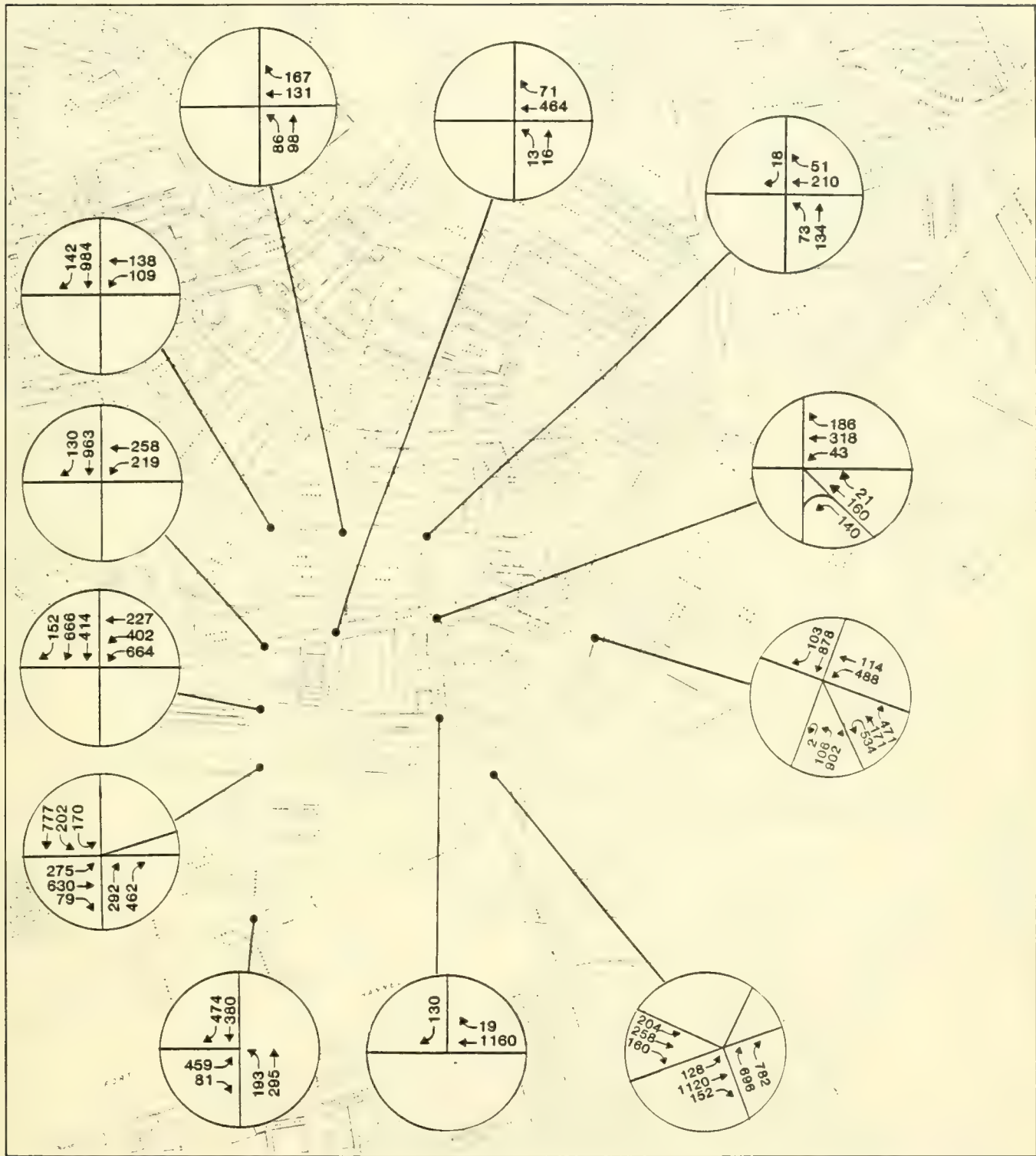
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Figure 3b - Existing AM Network



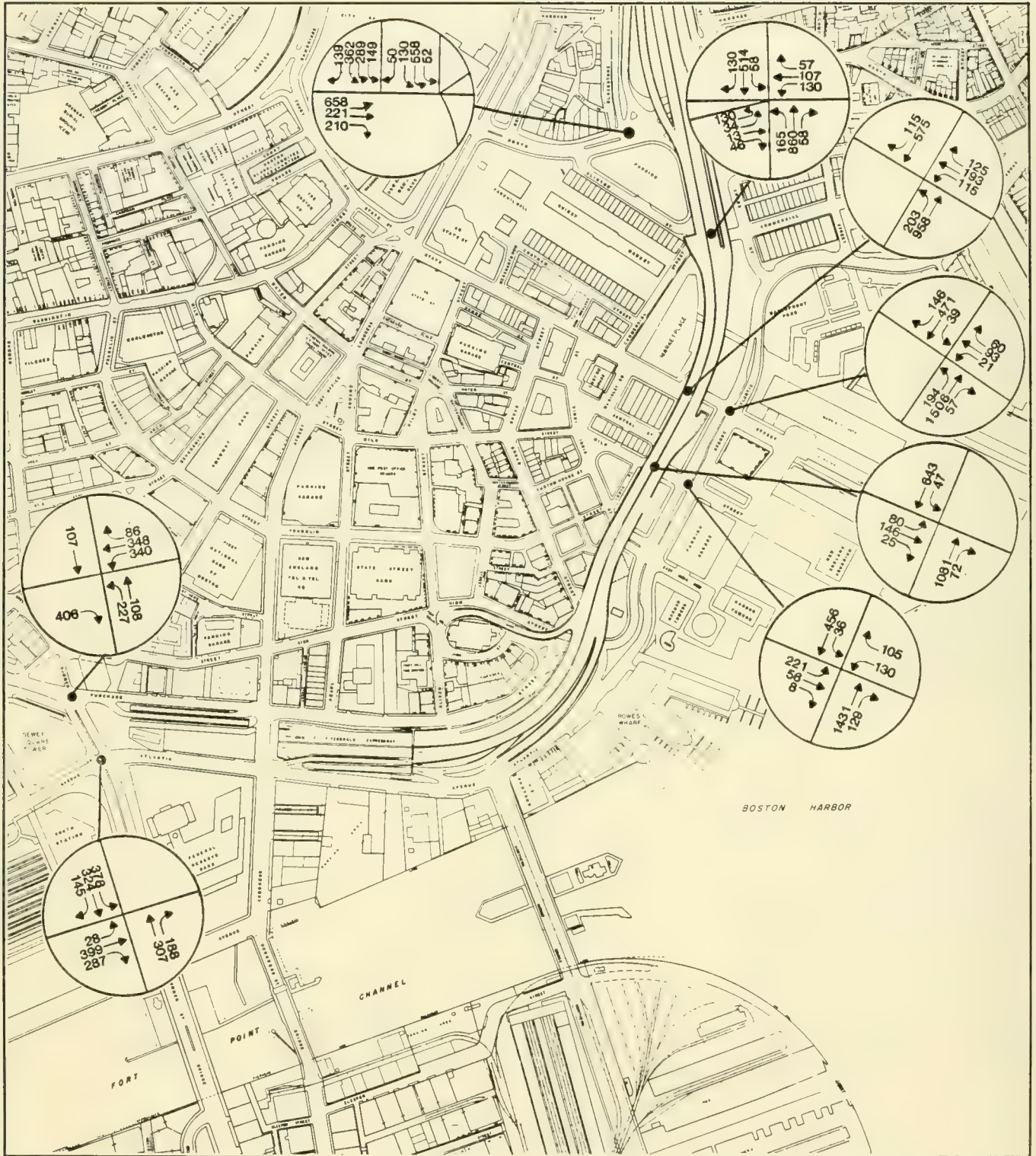
Figure 4a - Existing PM Network



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Figure 4b - Existing PM Network



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TABLE 1
TURNING MOVEMENT COUNTS

Location	Time Period	Month/ Year	Day	Source	Hour of Peak
Congress St./ Franklin St.	AM,PM	7/79	Wed.	Traffic Study for a proposed Multi-Story Office Building dated 1/81 by VHA (Counts from BTP)	
Congress St./ High St.	AM,PM	8/79	Wed./ Thurs.	Traffic Study for a proposed Multi-Story Office Building dated 1/81 by VHA (Counts from BTP)	
	AM,PM	80		Dewey Sqr. TSM Study by VHA (Traffic by S.G. Associates)	8-9 AM 5-6 PM
Congress St./ Purchase St.	AM,PM	80		Dewey Sqr. TSM Study by VHA (Traffic by S.G. Associates)	8-9 AM 5-6 PM
Congress St./ Atlantic Ave.	AM,PM	80		Dewey Sqr. TSM Study by VHA (Traffic by S.G. Associates)	8-9 AM 5-6 PM
	AM,PM	6/81	Mon.	Boston Traffic & Parking	
	PM	11/81	Tues.	Comm. Pier Five EIR by VHA dated 7/82	
Congress St./ Dorchester Ave.	AM,PM	12/76- 1/77	Thurs./ Fri.	Boston Traffic & Parking	
Atlantic Ave./ Northern Ave.	AM,PM	11/81- 12/81	Tues./ Weds.	Comm. Pier Five EIR by VHA dated 7/82	
High St./ Atlantic Ave.	AM,PM	10/79	Tues./ Weds.	Boston Traffic & Parking	
	AM,PM	11/80	Mon.	Traffic Study for a proposed Multi-Story Office Building dated 1/81	
	AM,PM	81		Comm. Pier Five EIR by VHA dated 7/82	
	AM,PM	82		Third Harbor EIR dated 12/82	
Franklin St./ Pearl St.	AM,PM	8/79	Fri.	Traffic Study for a proposed Multi-Story Office Building dated 1/81 by VHA (Counts from BTP)	
Franklin St./ Oliver St.	AM,PM	11/80	Thurs	Traffic Study for a proposed Multi-Story Office Building dated 1/81 by VHA	
	AM,PM	5/83		Boston Traffic & Parking	
High St./ Pearl St.*	AM,PM	11/80	Wed.	Traffic Study for a proposed Multi-Story Office Building dated 1/81 by VHA	
	AM,PM	9/79	Fri.	Boston Traffic & Parking	
High St./ Oliver St.	AM,PM	11/80	Wed.	Traffic Study for a proposed Multi-Story Office Building dated 1/81 by VHA	
	AM,PM	3/81	Thurs.	Boston Traffic & Parking	
Purchase St./ Oliver St.	AM,PM	9/76	Wed./ Thurs.	Boston Traffic & Parking	

TABLE 1
TURNING MOVEMENT COUNTS
(Continued)

Location	Time Period	Month/ Year	Day	Source	Hour of Peak
Atlantic Ave./ Summer St.	AM,PM	80		Dewey Sqr. TSM Study by VHA (Traffic by S.G. Associates)	
	AM,PM	12/81	Fri.	Comm. Pier Five EIR by VHA dated 7/82	
	AM,PM	82		Third Harbor EIR by VHA dated Dec. 82	
Atlantic Ave./ Milk St.	AM,PM	7/80	Thurs.	Boston Traffic & Parking	
	PM	7/84	Thurs.	VHA Count	5-6 PM
Atlantic Ave./ State St.	AM,PM	3/83	Thurs.	Boston Traffic & Parking	8-9 AM 4:30 - 5:30 PM
Surface Rd./ Clinton St.	PM	82		Market Place Ctr. EIR dated 4/83	4:30 - 5:30 PM
	AM,PM	7/84	Thurs	VHA Counts	8-9 AM 4:15 - 5:15 PM
Surface Rd./ State St.	AM,PM	82		Third Harbor EIR by VHA dated Dec. 82	
	PM	82		Market Place Ctr. EIR dated 4/83	4:30 - 5:30 PM
	AM,PM	6/83	Mon.	Boston Traffic & Parking Counts	
Surface Rd./ Milk St.	AM,PM	11/80	Mon. Tues.	Boston Traffic & Parking Counts	
	AM	7/84	Thurs.	VHA Count	8-9 AM
Blackstone St./ North St.	AM,PM	82		Third Harbor EIR by VHA dated Dec. 82	
	PM	82		Market Place Ctr. EIR dated 4/83	
	AM,PM	7/84	Fri.	VHA Counts	8-9 AM 4:15 - 5:15 PM
Purchase St./ Summer St.	AM,PM	80		Dewey Sqr. TSM Study by VHA (Traffic by S.G. Associates)	8-9 AM 5-6 PM
	AM,PM	82		Third Harbor EIR dated 12/82	

ADDITIONAL COUNTS

Atlantic Ave./ East India St.	AM,PM	4/81	Weds.	Boston Traffic & Parking Counts	
	AM,PM	3/84	Thurs./ Fri.	Rowes Wharf EIR dated 7/84	8-9 AM 4:30 - 5:30 PM
Surface Rd./ India St.	AM,PM	11/79	Weds.	Boston Traffic & Parking Counts	
Purchase St./	AM,PM	7/79	Thurs./ Fri.	Boston Traffic & Parking Counts	

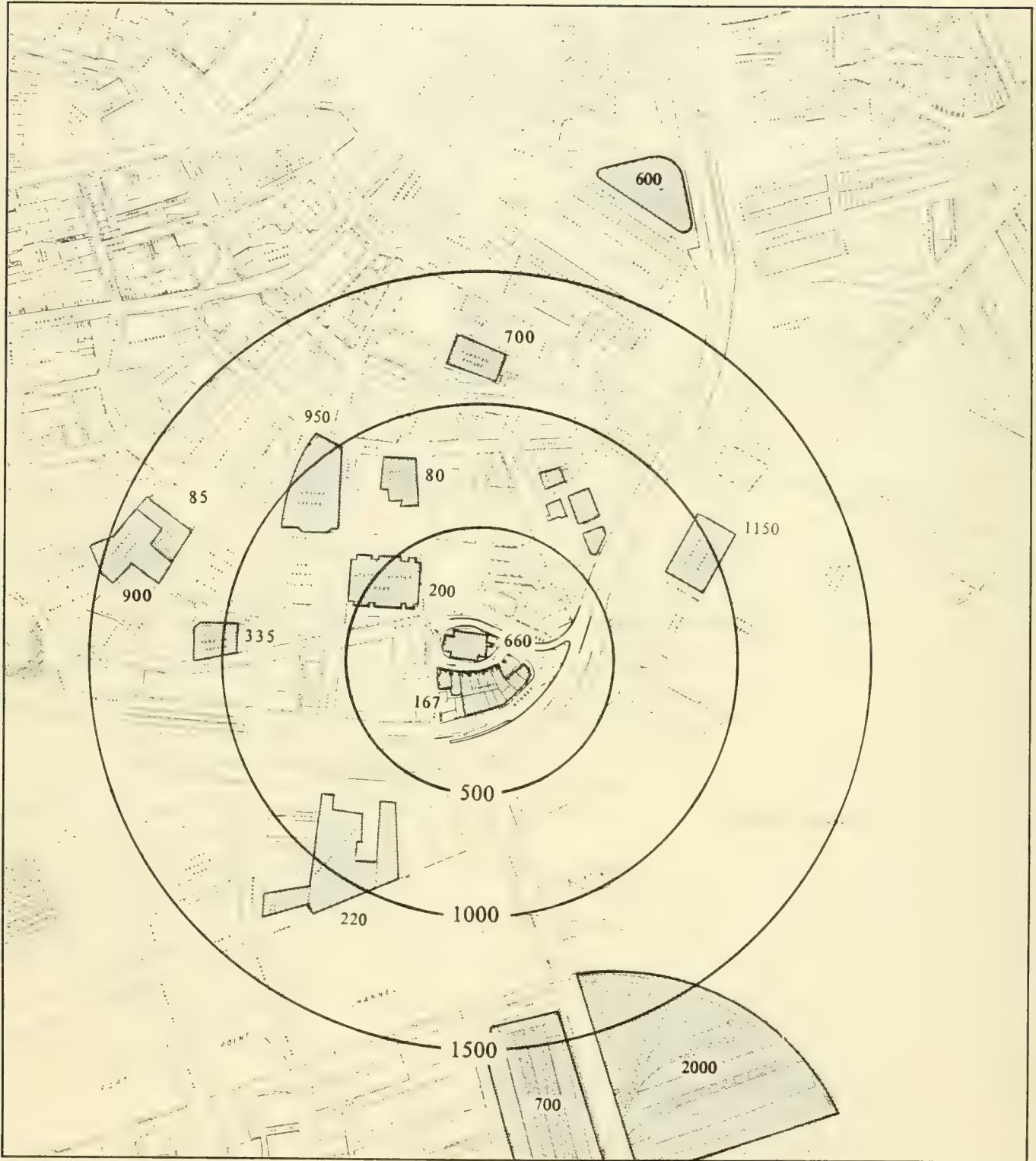
* Pedestrian Count

than the observed AM peak hour volumes. Traffic flows vary to some extent depending on the location of Central Artery on and off-ramps. In the morning there is a peak flow of approximately 620 vehicles on Purchase Street adjacent to the project. The comparative peak evening volume on this street is approximately 1,180 vehicles per hour. On High Street, south of Oliver Street, approximately 950 morning peak hour vehicles compare to 480 evening peak hour vehicles. This pattern is due to the High Street off-ramp from the Central Artery which provides morning commuters with a major connection to the local street system. In general, however, evening traffic flow levels are higher than morning conditions.

3. Parking System

Parking in downtown Boston is a primary concern to the proponent and business owner alike. The City of Boston has also indicated its concerns by undertaking a parking analysis in order to identify the parking needs with respect to accommodating future parking demands. Parking in the downtown is also at a premium with relatively high costs to the parker. According to a recent downtown survey, on-street parking is fully used while off-street spaces are used to 93 percent of capacity at peak (12 Noon to 2 PM). However, parking demands are not uniform and vary by type of parker and location in the City. Long-term or commuter parking tends to be located in off-street facilities while on-street parking generally accommodates high turnover parking.

Figure 5 - Major Existing Off-Street
Parking Facilities (Public Spaces)



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a) Off-Street Parking in Financial District/South Station Area

As noted in the Boston Parking Study^{1/} this area is one of the few areas of the City where there is presently a small surplus of long-term off-street parking spaces. Within 2,000 feet of the project site there are several parking facilities ranging in size from small, 10-15 space private lots to the 950-space Post Office Square Garage and 900 space Federal Street Garage as well as the large parking lots on Northern Avenue just beyond the Fort Point Channel. These facilities provide a total off-street supply of nearly 11,600 parking spaces within 1,500 to 2,000 feet from the project site. Figure 5 shows the major parking facilities in the area in relation to the proposed site.

The recent parking study conducted for the City of Boston included field observations of off-street parking activity in the area. Parking accumulation was noted during two time periods - 10:00 AM and 12:00 Noon - on several days during October, 1982. The results of these observations indicated that at 10:00 AM there was a surplus of nearly 2,000 off-street parking spaces in the 2,000-foot radius study area. By Noon, the surplus had decreased to approximately 1,200 parking spaces. Consequently, it appears there is currently some reserve capacity in the Financial District/South

^{1/}Cambridge Systematics, Inc., Parking in Central Boston: Meeting the Access Needs of a Growing Downtown, prepared for Boston Traffic and Parking Department, December 1983.

Station off-street parking system. Table 2 summarizes the existing parking supply/demand characteristics for the major parking facilities in the study area.

TABLE 2
OFF-STREET PARKING
FACILITY UTILIZATION

Facility	Capacity (Spaces)	Utilization		Available Supply
		10 AM	12 Noon	12 Noon
Bank of Boston (Private)	174	143	143	31
India Street Garage (Public)	184	92	111	73
Fort Hill Garage (Public) ^{1/}	660	585	585	75
One Post Office Square (Private/Public)	400	262	276	124
Kilby Street Garage (Public)	400	289	411	0
Post Office Sq. Garage (Public)	950	936	941	9
State Street Bank (Public)	200	167	190	10
Keystone Building (Private)	163	109	130	33
High Street Garage (Public)	335	107	230	105
Federal Street Garage (Public)	900	852	919	0
Harbor Towers Garage (Public/Private)	1,500	770	869	631
FAN Pier	2,000	1,904	1,908	92
Totals	7,856	6,216	6,713	1,173

^{1/} The supply figure was taken from the downtown parking study and was used throughout this analysis. There are actually 660 spaces in the garage and a site total (including the surface lots) of 827 parking spaces. The total of 827 was also used throughout this analysis.

Sources: Boston Parking Study Data
Field Observations by Vanasse/Hangen.

Since these observations were taken, there have been several changes in the parking supply. Several surface lots in the immediate vicinity of the project site have been eliminated by new construction. Most notably, building activity at 260 and 265 Franklin Street and Rowes Wharf have eliminated approximately two hundred spaces from the area supply. Increasing use of the surface parking on Northern Avenue across the Fort Point Channel, however, has offset this loss. Consequently, the overall area supply as reported in the Boston Parking Study is still valid. Similarly, with the exception of the Dewey Square Tower which falls within the 2,000 foot Study area, there has been little new building space put on the rental market since the parking survey at the time of this writing. Space which has been rented has been primarily small rehabilitation projects which has not significantly altered total area parking demand.

b) Current Parking on Site

As discussed earlier, the project site is currently occuppied by the City of Boston Fort Hill Mechanical Parking Garage, several small vacant or low use buildings and open surface parking. In total, their are 827 off-street parking spaces on the site, 660 in the parking garage and 167 spaces in the surface lot. The predominant use of the spaces in these facilities is by all-day parkers with much of the surface lot devoted to reserved monthly parking.

Recent field observations indicate the surface spaces are used to capacity on a regular basis. Discussions with the garage

attendant indicate lower utilization of the garage than was reported in the Boston Parking Study. However, for the purposes of this analysis, the Boston Parking Study data will be used.

c) On-Street Parking In Financial District/South Station Area

Unlike the off-street parking system, curbside parking appears to be used to capacity throughout most of the day. The Boston Parking Survey identified nearly 1,015 vehicles parked on-street in the vicinity of the site at 12 Noon. Virtually all of the available curbspace was utilized. At the time of the survey there were only 213 curbside metered spaces in the general study area and as was observed, a large number of motorists parked in either unmetered or otherwise restricted parking areas. It is important to note that the vast majority (over 80 percent) of those vehicles parking on-street stay for two hours or less according to the survey. It should also be noted that since the parking survey the City has increased the legal number of metered parking spaces in the Financial District/South Station area to approximately 926.

d) Parking Cost Characteristics

One area which can have a significant effect on parking demand characteristics is the cost of parking. A pricing policy attempts to encourage efficient use of parking spaces, typically by charging high rates for short-term spaces and lower rates in location where all day parking is to be encouraged.

As part of the downtown parking study, a survey of 98 percent of the public spaces in the study area was conducted to determine the one hour and all-day parking rates. At the time of that study, the average one hour rate in the Financial District area was found to be \$2.03, while the average rate for all day parking was found to be \$5.44. In close proximity to the site (across the Fort Point Channel) long-term parking costs approximately \$2.00 to \$2.50 all day.

In 1972, average one hour and eight hour parking rates Citywide were \$0.82 and \$2.50^{1/}. These 1972 rates, expressed in 1982 dollars are \$1.89 and \$5.77. Thus, the cost of one hour parking has increased a small amount over inflation (\$1.89 in 1972 versus \$1.92 in 1982), while the cost of all day parking has actually decreased in constant dollar terms (\$5.77 in 1972 versus \$5.16 in 1982).

Since the survey was taken parking rates have generally increased. Long-term parking in the vicinity of the site ranges from \$6.00 to \$10.00 per day. Research^{2/} has indicated that as daily parking rates increase and enforcement of parking regulations are consistent and at high levels, parking demand will likely decrease. Elasticity values vary from 0.29 for the price elasticity of demands and 1.6 for the price elasticity of total parking fee collections. For example, the price elasticity indicates that for

^{1/} Wilbur Smith Associates, "An Access-Oriented Parking Strategy for the Boston Metropolitan Area", July 1974, pg. 120.

^{2/} New York State Department of Transportation, Energy Impacts of Transportation System Management Actions in New York State, 1978-1980, Pre 155, May, 1979.

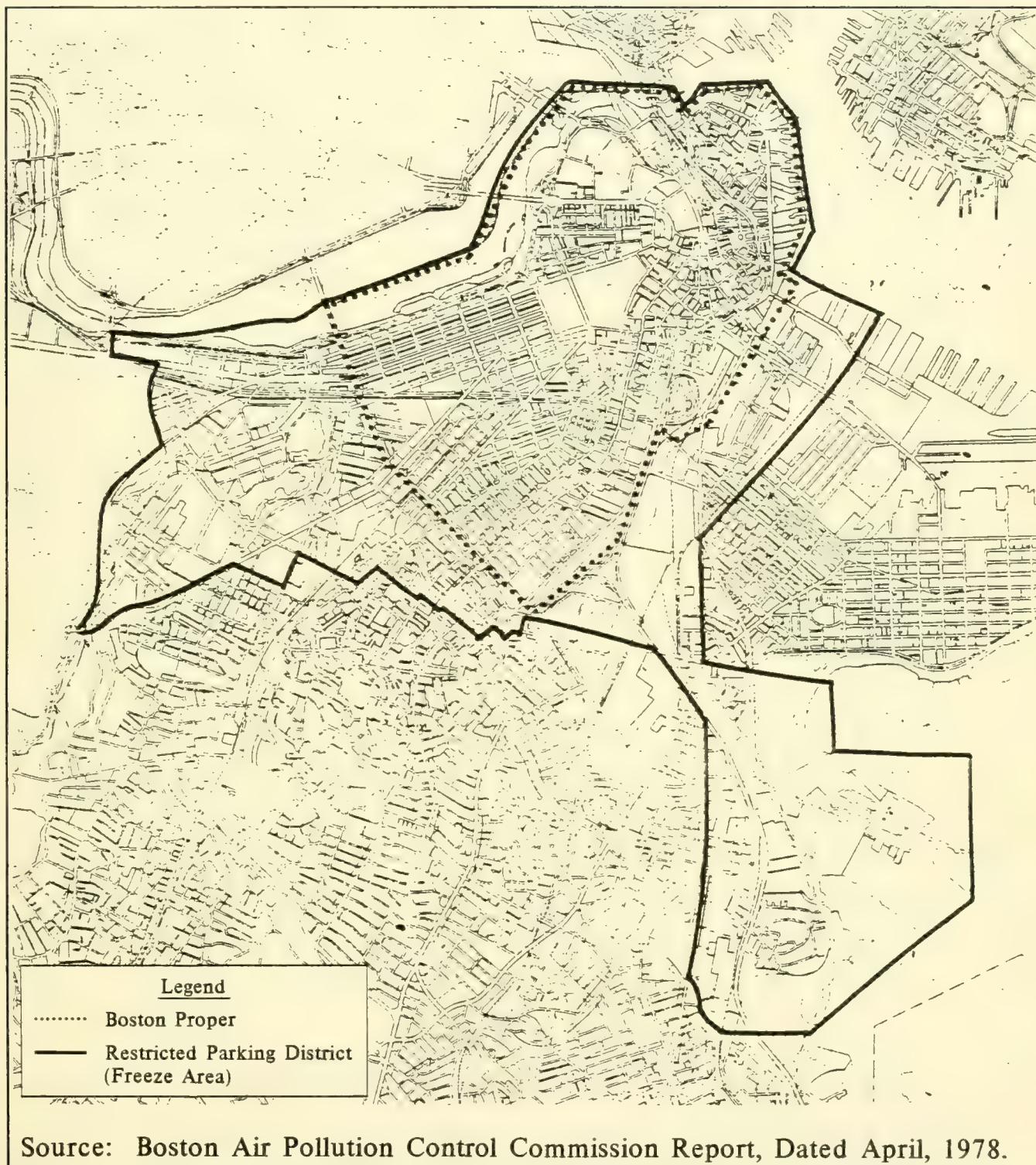
every one percent increase in price, an 0.29 percent decrease in demand will occur. Parking taxes, which actually become hidden in the fee, have a relatively strong effect on long-term demand.

Therefore, it is important to recognize that existing parking demand observations as well as future parking demand estimates which are projected based on current pricing, could potentially be lower as parking costs inevitably increase. If costs to the commuter become high enough, alternative modes which are less costly will be sought (i.e. park and ride, carpooling transit).

e) Downtown Parking Freeze

In an attempt to control the number of vehicles in the downtown area and improve the air quality, a parking freeze program became part of the State Implementation Plan in response to Federal mandates to improve air quality. Instituted in 1976, the present freeze on commercial parking spaces in downtown Boston limits the number of commercial spaces to the 1973 level of 35,503. New construction of these spaces can be done only after the Boston Air Pollution Control Commission (BAPCC) issues a freeze permit. Figure 5a shows the boundary of the parking freeze. It can be seen that the Fort Hill area falls within the freeze boundary. Under the current freeze program the Fort Point Channel area is not within the freeze area, but is what the City has defined as a restricted parking district.

Figure 5a - Parking Freeze Area



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Freeze permits are issued contingent on the proposed facility meeting the BAPCC's criteria, which are:

- Sufficient spaces are available in the freeze bank. (Spaces are added to the bank when on- or off-street parking spaces are removed in the freeze area);
- The facility will not add parking to an area already adequately served by existing parking facilities or with adequate transit access;
- It will not contribute significantly to peak period traffic;
- It is located and designed so that the surrounding sidewalks and streets are sufficient to accommodate pedestrians and vehicular movements;
- It has satisfactory access to major highways serving the area;
- It directly serves development in the surrounding area, and
- Its design, including height, bulk, ground floor use, and landscaping, is in accordance with and consistent with architectural and land use patterns in the surrounding area and is itself aesthetically pleasing.

All non-commercial spaces, including residential, and reserved employee and visitor spaces are exempt from the freeze. However, the BAPCC must grant a special exemption before non-commercial facilities may be constructed.

The BAPCC began administering the freeze in 1976. In 1981, the City of Boston conducted a study^{1/} to assess its impacts to date. This study essentially showed that the freeze appears to have been successful in limiting the number of commercial spaces, restrained automobile usage, increase transit usage, while downtown development continued to occur.

Although the freeze has apparently been successful and its objective generally achieved, the City conducted a detailed review of the freeze as part of the recent parking study. A review of the program appeared reasonable for several reasons including the following which were stated in the 1983 Parking in Central Boston Study mentioned earlier:

- Unprecedented downtown development has occurred, increasing office square footage by 35 percent between 1973 and 1982 while an additional 6 million square feet of office and retail space are planned to come on line between 1982 and 1985.
- Peak occupancies of downtown parking facilities have increased from 82 percent in 1972 to 93 percent in 1982. The occupancy level is sufficiently high to trigger concern about meeting the needs of new development, and in particular, the midday parker.

^{1/} Ellen Collins, Boston Redevelopment Authority, Transportation Planning Department, "Downtown Boston Parking Programs", prepared for the Traffic and Parking Department, City of Boston, sponsored by the Metropolitan Area Planning Council, July, 1981.

- Presently, more than 5,000 cars are parking in surface lots in the Fort Point Channel/South Boston industrial area, which presently serves as a "pressure valve" for financial district parking needs. As development replaces surface lots in this area, the parking needs of both the Fort Point Channel and the financial district will have to be addressed.
- The economics of parking construction have changed dramatically, due to rising interest rates and construction costs. This change has made many developers reluctant to build more parking than they feel absolutely necessary for the economic viability of their buildings.
- Recent downtown parking initiatives in Boston have emphasized meeting the needs of residents and short-term parkers through reserving on-street space in neighborhoods for residential use, expanding the overall on-street parking supply and strictly enforcing these spaces to maintain a high turnover.
- New, innovative strategies are being successfully pursued in many cities throughout the country, which make approval of new development contingent on developer and/or employer commitments to transit and ridesharing incentive programs. These programs have proved to be very effective in increasing the use of transit, carpools and vanpools to the site, which alleviates traffic and parking pressures.

As a result of the 1983 parking study, several recommendations were made. These recommendations are still in the process of being reviewed and ramifications being determined. Specifically, the recommendations included (but were not limited to):

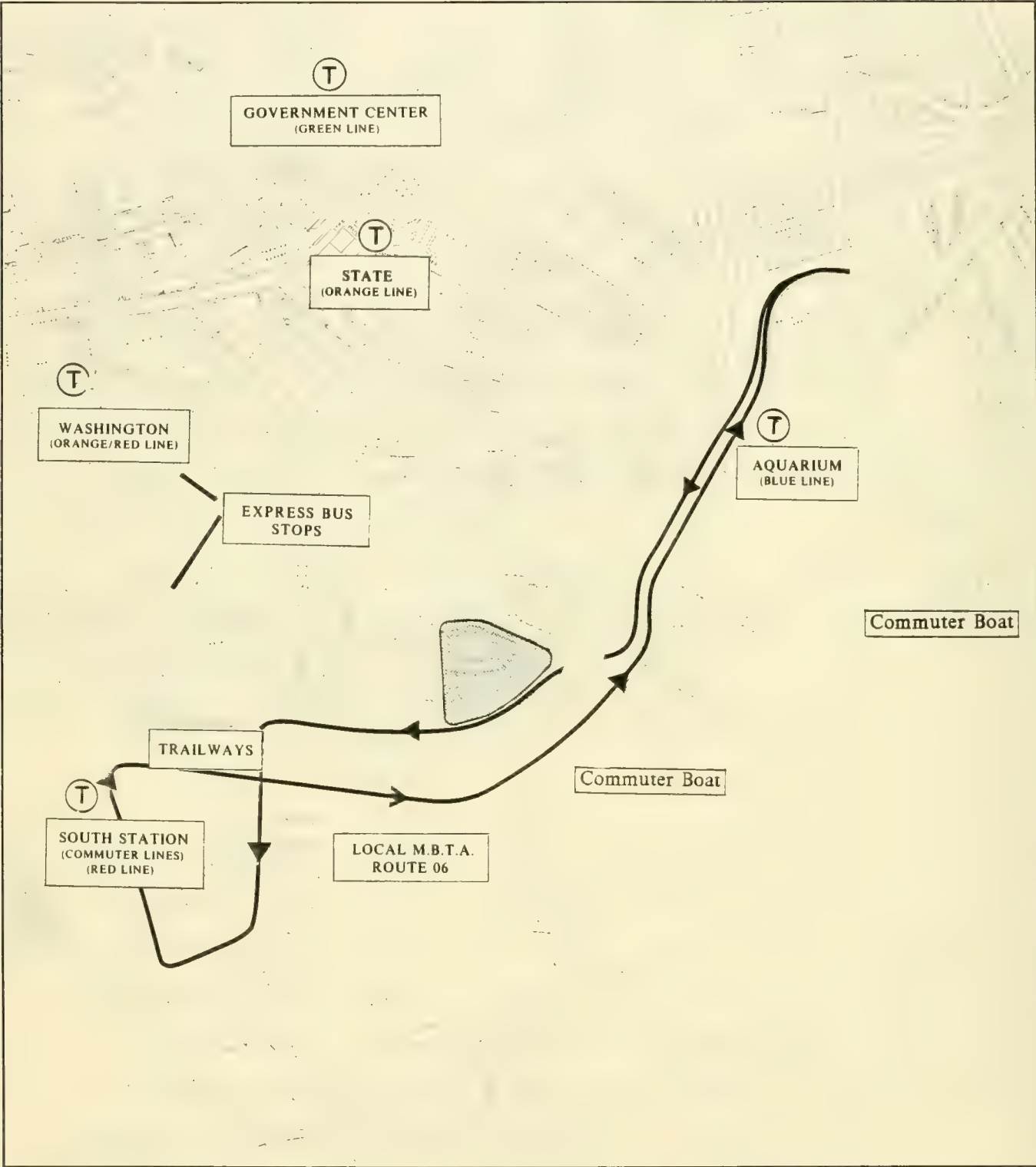
- increasing the South Station parking supply,
- increasing the North Station parking supply,
- develop a midday parking bank, and
- develop a parking management plan for Fort Point Channel.

The study's recommendations are discussed in more detail later in this report. As stated earlier, improvements such as increasing the legal number of metered on-street spaces is already taking place. Any improvements which require modifying the freeze requires further air quality studies and State and Federal approvals. It should be noted, however, that modifying the freeze does not imply changes to the freeze area boundary and it is currently anticipated that the boundary will not change.

4. Transit System

International Place is well served by public transportation in that 3 subway stations are within 1,500 feet of the site. Figure 6 shows the existing transit facilities in the area. They include the Red, Orange, and Blue subway lines, commuter rail and bus service. The Green line station at Government Center is within a half mile of the site and provides more limited service. In addition, commuter boat service has increased its service over the last several years. These different types of transit are briefly discussed below.

Figure 6 - Existing Transit System



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a) Subway System

• System Description

The MBTA operates rapid rail vehicles over three separate lines. The Red line extends from Harvard Square in Cambridge through downtown Boston to Columbia Station in South Boston. At that point, it divides into two branches; one that continues through Quincy to Braintree and one that terminates in Dorchester. At South Station^{1/}, a connection can be made between the Red Line and the commuterail system.

The Orange line extends from Forest Hills Station in Jamaica Plain through Roxbury and the South End, to downtown Boston. It then continues northward through Charlestown and Medford into Malden. The State Street station^{2/} serves the project site most conveniently. North Station provides a connection between the Orange Line and the commuter rail system to the North. Although a recent fire has temporarily halted commuter rail service to North Station, reconstruction plans are proceeding in order to resume this service.

^{1/} South Station is located approximately 1,750 feet away from the site.

^{2/} The State Street subway station is approximately 1,700 feet of the site.

The MBTA's blue line originates at Wonderland Station in Revere and travels through East Boston into downtown Boston (Aquarium Station)1/. A connection to Logan Airport can be made using the Blue Line.

As will be discussed later in this report, two major projects are currently being undertaken to improve the rapid rail system. The Southwest Corridor Project involves the relocation of the Orange line south of Essex Station to a railroad right-of-way west of the existing elevated line. This segment will be approximately 4.7 miles long with eight new stations. The line will share the right-of-way with long-distance commuter rail services, which will also use three of the eight stations.

The Northwest Extension Project involves the construction of a 3.2 mile extension of the Red line between Harvard Square and Alewife. This segment will contain three new stations, with a 2,000 space parking garage at the terminus (Alewife).

The MBTA provides light rail service on the Green line and Mattapan High Speed line. The Green line runs from Lechmere Station in East Cambridge through downtown Boston where it branches into four lines. The Arborway line runs from Copley Square to Jamacia Plain; the other three lines carry passengers between Kenmore Square and either the Riverside or Boston College in Newton, and Cleveland Circle in Brighton. Service on the Mattapan trolley line, which runs between Mattapan Square and Ashmont Station in Dorchester, was restored in January, 1981 following track improvements.

1/ The Aquarium station is approximately 1,400 feet from the site.

Table 3 summarizes the line characteristics of the subway system.

o Ridership

Table 4 summarizes ridership data obtained from the MBTA for the different subway lines. Indicated in the table and summarized below are the peak period ridership^{1/} in the peak direction. For example, during the evening, outbound trips represent the peak direction. Vehicle passenger counts were the basis for these ridership figures. In addition, the table shows peak hour factors which are a measure of the passenger count during the peak 15 minute period relative to the count during the entire peak hour. This factor is somewhat informative, however, it is highly dependent on vehicle arrivals during each 15 minute period.

A peak southbound Red Line ridership of 12,120 passengers has been observed during the evening peak hour at Andrew Station. This is a total of the Ashmont and Braintree routes. The Passenger counts which are dependent on arrival of vehicles show moderate peaking on the Ashmont Line, while on the Braintree Line there is significant short-term peaking. At the Charles Street Station, Cambridge-bound passengers amount to 6,440 during the peak hour with moderate peaking.

^{1/} Ridership was received from MBTA Operations Department and represents the most recent passenger counts at peak load points along each of the lines.

TABLE 3
EXISTING LINE STATISTICS AND CAPACITY

	PM Peak Period Line Statistics				
	Cars/ Train	Headway (Minutes)	Trains/ Hour	Capacity/ Car	Capacity/ Hour
<u>Red Line</u>					
Harvard - Ashmont	4	6	11	244	10,740
Harvard - Braintree	4	6	11	244	10,740
Ashmont & Braintree - Harvard	4	3	22	244	21,480
<u>Green Line</u>					
North Station - Cleveland Circle	1	4	16	214	3,420
Government Center - Boston College	1	4	16	214	3,420
Lechmere - Riverside	1	3.3	19	214	4,070
Park Street - Arborway ^{2/}	2	3.75 ^{2/}	17	126	4,280
Riverside - Lechmere	1	3.3	19	214	4,070
<u>Orange Line</u>					
Oak Grove - Forest Hills	4	4	16	197	12,600
Forest Hills - Oak Grove	4	4	16	197	12,600
<u>Blue Line</u>					
Bowdoin - Wonderland	4	4	16	139	8,900

^{1/} Based on seating capacity plus 1.75 square foot per standee.

^{2/} Heath Street loop runs at 7.5 minute headways complementing the Arborway - Park Street Route and effectively yielding 3.75 minute headways.

TABLE 4
EXISTING RAPID TRANSIT RIDERSHIP^{1/}

Line/Station	Route	Peak Hour Ridership	Peak Hour Factor ^{2/}	Ridership Capacity ^{3/}
<u>Red Line</u>				
Andrew Station	Harvard - Ashmont	4,630	0.78	0.43
Andrew Station	Harvard - Braintree	7,490	0.65	0.70
Charles Station	Ashmont & Braintree - Harvard	6,440	0.75	0.30
<u>Green Line</u>				
Arlington Station	North Station - Cleveland Circle	2,420	0.90	0.71
Arlington Station	Government Center - Boston College	2,120	0.59	0.62
Arlington Station	Lechmere - Riverside	2,500	0.93	0.61
Arlington Station	Park Street - Arborway	2,090	0.84	0.49
Science Park	Riverside - Lechmere	1,100	0.88	0.27
<u>Orange Line</u>				
Essex Station	Oak Grove - Forest Hills	7,080	0.60	0.56
North Station	Forest Hills - Oak Grove	10,270	0.89	0.82
<u>Blue Line</u>				
Aquarium Station	Bowdoin - Wonderland	6,120	0.77	0.69

^{1/} MBTA traffic counts at peak load point stations of in-vehicle passengers during the PM Peak Period.

^{2/} Peak hour factor indicates the extent to which a peak hour volume contains a surge of passengers during a fifteen minute period. A value of 0.60 shows significant surging while values approximating 1.0 indicate uniform passenger flow during the hour.

^{3/} See Table 2 for existing line capacities.

On the Green Line, four routes to Cleveland Circle, Boston College, Riverside and Arborway were observed at Arlington Station. A total outbound peak hour ridership of approximately 10,000 passengers exhibits minimal to significant 15 minute peaking. For example, the Cleveland Circle and Riverside counts exhibits minimal peaking while the Arborway passengers count shows a moderate peak and the Boston College Line shows significant short period peaking. At Science Park, the Lechmere bound passenger count indicates minimal peaking.

Orange Line evening peak period counts show 7,080 passengers heading south at Essex Station and 10,270 heading north at North Station. A heavy concentration of vehicles during one 15 minute period was observed concurrent with an apparent peak southbound passenger flow, while northbound, slight peaking was observed during the peak hour.

Outbound passenger flow (6,120 passengers) on the Blue Line are observed to peak slightly as do the number of vehicles passing through Aquarium Station.

Also shown in Table 4 is a comparison of existing ridership to the line capacity. As seen in the table, all lines are currently operating below capacity.

Current Performance

The Operations Directorate of the Massachusetts Bay Transportation Authority records performance criteria on a daily

basis. Reports such as "Performance Indicators" and "MBTA Service Tracking Report" present summaries of all the following indicators:

Throughput Performance;

Vehicle Trips Not Run;

Vehicle AM Availability;

Mean Distance Between Failure;

Miles Since Previous Scheduled Service and Inspection (5,000 Mile Standard);

Disabled Vehicles;

Electronic Controllers and Pass Reader Equipment;

Service Call Report; and

Vehicle Cleanliness: Weekly Percentage of Vehicles Passing Pull Out Inspection (Eight Garage Total).

These indicators enable identification of problem areas on the system which would be targeted by future maintenance and efficiency programs. For the purposes of this study, a complete illustration of these indicators would be inappropriate, however, to gain some insight into the reliability of service schedules. Throughput performance is shown in Table 5. Throughput performance relates the actual number of trains run relative to the scheduled number of trains. Sometimes due to equipment or system failure, this number is less than 100 percent and other times to meet demand or when the system is running better than expected, the percentage is greater than 100. Within this table, rapid transit routes are listed and

associated with throughput performance percentages pertaining to each route's record during the week of July 20, 1984. This representative week shows the most recent available data.

TABLE 5
RAPID TRANSIT PEAK PERIOD^{1/}
THROUGHPUT PERFORMANCE^{2/}

Line	Route	Throughput Performance			
		AM (Percent)		PM (Percent)	
		Avg.	Range	Avg.	Range
Red	Braintree (NB)	90	80-96	88	80-103
	Braintree (SB)	81	70-85	88	77-103
	Ashmont (NB)	94	86-100	107	105-110
	Ashmont (SB)	102	90-110	99	94-100
Green	Cleveland Circle	100	90-105	97	90-104
	Riverside	100	96-102	92	78-102
	Boston College	95	88-100	92	82-102
	Arborway	106	95-112	108	90-120
Orange	Forest Hills	99	83-108	99	95-102
	Oak Grove	107	100-113	97	92-103
Blue	Downtown	100	97-107	99	85-105

^{1/} Peak Period = 6:30-9:30 AM, 3:30-6:30 PM.

^{2/} Average Daily Percentage of Weekday scheduled trains operated week of July 20, 1984.

The indicator will vary and on some routes the variation is significant. The greatest variation has been seen on the Red Line's Braintree-Harvard route. Simply, the overall meaning of this indicator, 100 percent Throughput Performance provides the least amount of unexpected delay to passengers.

As can be seen in the table, the throughput performance is generally high, however, can vary considerably day to day. Currently the most consistent lines appear to be the Orange and Blue Lines which experience average performance close to 100 percent

based on the data observed, Green Line service although experiencing a high average performance value, varies substantially day to day, particularly the Riverside and Boston College Lines. The Red Line; as widely recognized by the MBTA, State and local officials, currently experiences the most inconsistency as related to throughput performance or reliability.

According to MBTA officials, this is largely due to rail and electrical deficiencies which hopefully will be corrected over the next several years with implementation of scheduled improvements.

As stated above, the throughput performance measures are reported to be relatively high. However, the effect of 1 train or a series of trains not making scheduled runs can significantly effect passenger travel times, crowding on the platform as well as crowding on the trains affecting overall ride quality.

● Commuter Rail Service

In addition to the subway system, the MBTA operates an extensive commuter rail system with one hub at South Station (southern division and one at North Station (northern division), (a recent fire has temporarily halted service to North Station, however, it is anticipated to be restored within the next two years). The system is operated by the Boston & Maine under contract to the MBTA. Transfers to the subway system are accommodated at each hub (Red Line at South Station, Orange and Green Lines at North Station).

In total there are 8 branches serving the north, west and south. Four branches (Framingham, Franklin, Shore, and Stoughton) terminate at South Station. Serving North Station are the Eastern, Reading, New Hampshire, and Gardner/Fitchburg branches. Table 6 summarizes the existing operating characteristics of the commuter rail service.

TABLE 6
SUMMARY OF EXISTING COMMUTER RAIL SERVICE

Line	Number of Trips		Peak Period Seating Capacity ^{1/}		Peak Period Ridership ^{2/}	
	AM	PM	AM	PM	AM	PM
Framingham	4	4	2,300	1,700	2,210	1,815
Franklin	5	4	2,800	2,400	3,000	2,505
Shore	5	5	2,800	3,300	2,935	2,640
Stoughton	4	3	2,200	1,500	2,070	1,170
Eastern	6	6	2,300	2,300	2,530	2,140
Reading	6	5	2,400	2,000	1,825	1,440
New Hampshire	6	6	1,700	1,600	1,110	1,140
Gardner/Fitchburg	4	4	1,300	1,200	1,230	1,045

^{1/} Represents winter 1984 data.

^{2/} Seating capacity is based on 100 seats per car.

Source: MBTA Commuter Rail Section.

As can be seen, overall peak period ridership on the commuter rail system generally does not exceed the seating capacity. However, there are instances where standees exist on various train trips. According to the MBTA, train cars are added when it becomes necessary in order to meet the demands and the demands justify another car.

According to the MBTA when the number of standees on a particular train approximates 50, the B&M will generally request approval for an additional car. Before adding a car to a train, the MBTA will review the economic consequences in order to be relatively certain that the addition can be economically justified.

One problem the MBTA has faced over the past few years is having the equipment available to meet the increasing demands. To address this problem in the short term, the MBTA has leased cars from the Toronto system until 1987. In the meantime, the MBTA has forwarded plans to acquire more cars for all its lines.

● Bus Service

The study area generally is served by six different MBTA surface bus routes. One route provides local service within Boston while the other five provide Express bus service between Downtown and outlying suburbs along the Massachusetts Turnpike. Table 7 summarizes each route by name, number and type of service while Figure 6 shown previously indicated the routing of Route 06, 06-1.

TABLE 7
EXISTING MBTA SURFACE BUS ROUTES

Route Number	Name	Type of Service
06, 06-1	Army Base - Haymarket/South Station (Essex/Washington)	Local
300	Riverside - Downtown	Express
301, 301-1	Brighton Center - Downtown	Express
304, 304-1	Watertown - Downtown	Express
305	Waltham - Downtown	Express
310	Needham - Downtown	Express

In addition to the MBTA bus service, intercity service is also provided by private carriers with a connection to the study area via South Station the Trailways terminal located two blocks from the project site.

In regards to the MBTA service, Route 06 is the only local service route which can directly serve the project as it runs between Haymarket, South Station and the Boston Army Base.

Four of the five express bus routes travel the same streets to reach the Downtown Financial District. The general pattern is a counterclockwise loop with buses entering the area via the Atlantic Avenue Turnpike off-ramp. Express buses cross Kneeland Street and proceed north on South Street to High Street. Current practice is for the express buses to use a short contraflow bus lane on High Street to reach Federal Street (particularly during the morning). All buses turn left on Federal Street and complete their loading at the two major stops (The First National Bank on Federal Street and the Shawmut Bank on Franklin Street).

On a daily basis, a total of approximately 1,027 one-way bus trips are made into or out of the Financial District in the vicinity of the study area. This figure includes buses entering as well as those exiting the area and counts each separately. Thus, averaged over an entire day, approximately 514 buses serve the Downtown area on the six routes. Table 8 summarizes the existing weekday trip schedule by period of the day for local and express service.

TABLE 8
EXISTING MBTA SERVICE
WEEKDAY TRIP SUMMARY
WINTER, 1983 SCHEDULE

LOCAL SERVICE										
Route ^{1/}	7:00 AM - 8:59 AM		9:00 AM - 2:29 PM		2:30 PM - 5:29 PM		5:30 PM - 7:00 AM		All Day	
	In	Out	In	Out	In	Out	In	Out	In	Out
06,06-1	10	9	10	8	11	8	8	7	39	32
EXPRESS SERVICE										
Route	7:00 AM - 8:59 AM		9:00 AM - 3:59 PM		4:00 PM - 5:59 PM		6:00 PM - 6:59 AM		All Day	
	In	Out	In	Out	In	Out	In	Out	In	Out
300	24	26	22	24	22	26	20	24	88	100
301, 301-1	46	41	27	32	40	57	24	31	137	161
304, 304-1	20	22	18	20	20	27	18	20	76	89
305	26	29	25	27	27	34	25	27	103	117
310	25	2	7	9	6	22	8	6	46	39
Subtotal	141	120	99	112	115	166	95	108	450	506
TOTAL	151	129	109	120	126	174	103	115	489	538

Source: MBTA Systems Planning Office

^{1/} Where discrepancies existed between route summaries and schedule information, the schedule was used to determine trips.

Of the total, express routes account for approximately 92 percent of the bus trips made in the study area while the local routes make up the remaining 8 percent. This factor indicates the overall relative importance of the Express Routes which serve the Financial District study area.

Table 9 shows the number of express bus passengers entering the study area, followed by the number of passengers leaving the study area during each peak period via the express bus service. The results indicate that together, the five express bus routes typically carry approximately 4,400 passengers during each of the peak periods. Of this total, the vast majority (approximately 95 percent) enters the Financial District/South Station area during the AM peak period. Similarly, during the PM peak period, 95 percent of the riders leave the area. All totaled, the five express routes carry over 8,800 passengers on a typical weekday during the two commuter peaks.

TABLE 9
EXPRESS BUS PASSENGER VOLUMES
FEBRUARY, 1982

Route	AM Period 6:00-10:00 AM		PM Period 2:00-7:30 PM		Total	
	In	Out	In	Out	In	Out
300 ^{1/}	755	72	43	867	798	939
301	877	4	11	766	888	770
304	1,119	79	148	1,259	1,267	1,338
305	617	38	22	507	639	545
310	<u>868</u>	<u>16</u>	<u>25</u>	<u>740</u>	<u>893</u>	<u>756</u>
Total	4,236	209	249	4,139	4,485	4,348

^{1/} Outbound and PM volumes on Route 300 taken January, 1983.

Ridership data on the local bus route 06 which serves the project site indicates that during the AM and PM peak periods, approximately 550 passengers are carried.

● Commuter Boat

An increasingly important part of the public transportation system serving downtown Boston is the commuter boat service. Although carrying fewer passengers than other forms of transportation, there has been an increased emphasis on improving the service.

Commuter boat service to and from the South Shore is provided by service from Hull (50 minutes), Hingham (30 minutes), and Quincy (25 minutes). A total of 11 boat trips operate during morning and evening peak commuter periods and can accommodate more than 1,500 passengers. These passengers are protected from the weather in fully enclosed spaces. All but one of the trips are made from the Rows and Fosters Wharves with the exception docking at Long Wharf. Recent reconstruction of the southeast expressway has prompted some of the added service which has been met by a continuous increasing demand for the overwater service. Specific capacity and ridership information is provided in Table 10.

TABLE 10
PEAK PERIOD^{1/} COMMUTER BOAT SERVICE

From	To	Trips	Capacity	Ridership
Hingham	Rows Wharf	8	1,019	575
Hull	Long Wharf	1	300	100-200 ^{2/}
Quincy	Fosters Wharf	2	278	50-65

^{1/} 6:00 AM - 9:30 AM and 3:15 PM - 7:30 PM.

^{2/} Highly seasonal.

There is the potential for increased commuter boat usage as increased emphasis is being placed on this mode even at the State level. With respect to the International Place Site, the commuter boats docked at Rowes Wharf are conveniently located. Commuters coming off the boats would have approximately a 700 foot long walk to the Purchase Street entry courtyard of the project.

This relatively convenient location combined with improved facilities and increased marketing may offer an attractive alternative mode for International Place commuters.

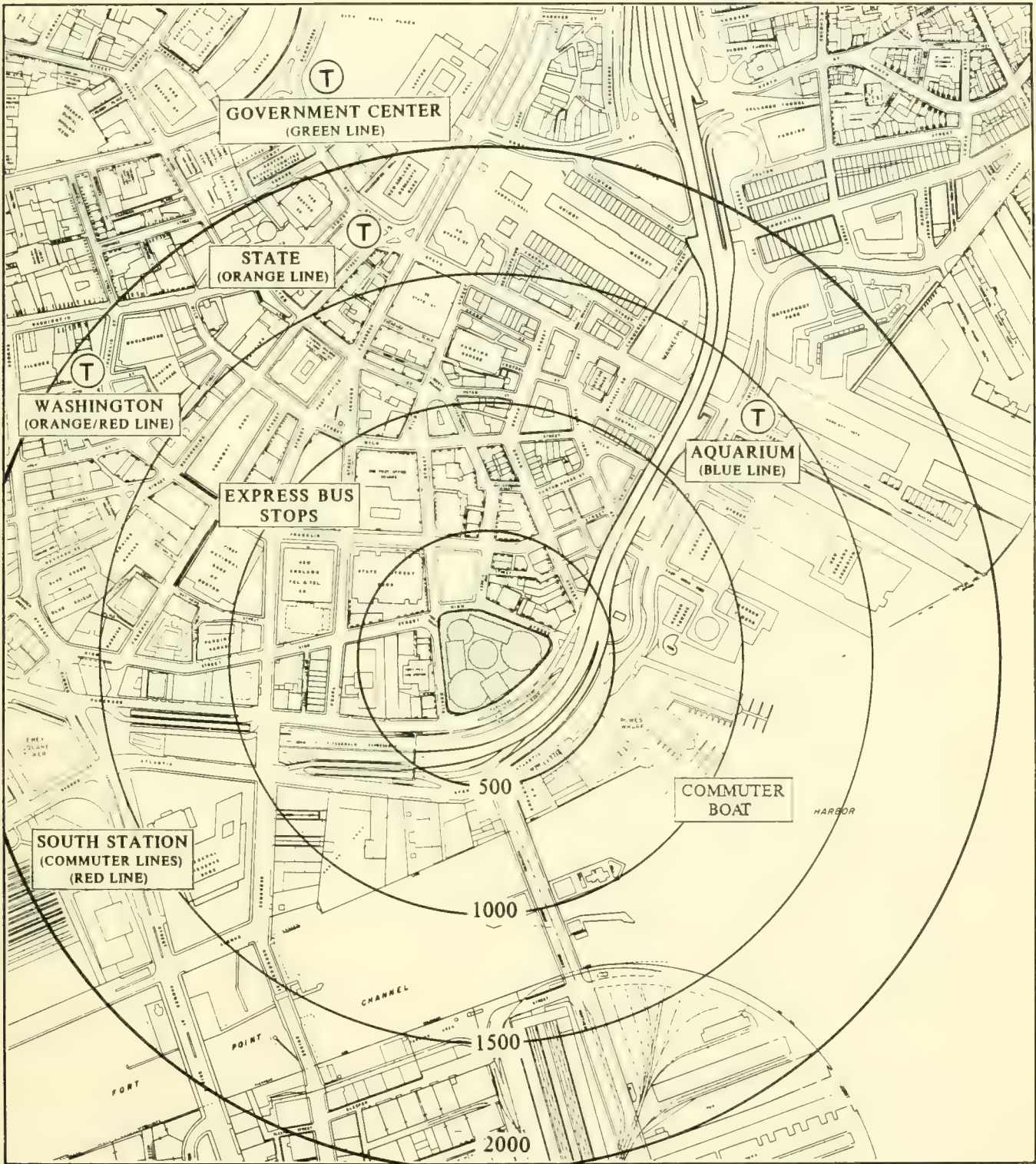
5. Pedestrian Characteristics

Existing pedestrian facilities and walking patterns were observed for the study area during both the morning and evening commuter peak hours. The purpose of the observations was to identify the pedestrian flow in relation to the proposed site. The observed locations included the surrounding transit stations, the express bus stops, as well as key office buildings in the vicinity of the site. Figure 7 identifies each transit station in relation to the distance from the site. From the figure, the approximate distance of each transit location was estimated and is summarized in Table 11 below.

TABLE 11
APPROXIMATE WALKING DISTANCES
TO KEY TRANSIT LOCATIONS

Location	Distance (feet)	Walking Time (minutes)
Aquarium Station	1,450	5
Government Center Station	2,300	8
South Station	1,750	5
State Street Station	1,750	5
Express Bus Stops	1,250	4

Figure 7 - Pedestrian Distances Between Site and Transit Stations



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Boston, MA

As will be discussed later in the report, the field observations formed the basis in developing the likely pedestrian paths from the transit locations toward the study area. During the morning and evening commuter peak hours, the pedestrian flow demand will be most concentrated between these locations. These walking paths represent the shortest distance to and from the proposed site area.

The condition of the existing crosswalks and sidewalks of the streets, which form the pedestrian paths, have also been observed to have adequate width (typically 5 to 15 feet wide) and capacity to carry the pedestrian flows during both the morning and evening commuter peak periods. The pavement markings indicating crosswalks and general sidewalk condition along the paths are generally in good condition.

It was also observed that most traffic signals located within the study area have either exclusive pedestrian phases built into the signal timing or have concurrent pedestrian phases where one-way street patterns allow for this operation. Pedestrian signal heads are also included at most traffic signal control locations. At crossings which are located at unsignalized intersections, the traffic volumes are relatively light and do not pose a problem in crossing the street.

As was suggested in the MEPA scope, observations indicate that there is some tendency for pedestrians to cross streets in a manner which interferes with traffic flow, although usually having protected pedestrian crossing phases. This is particularly true in

Dewey Square where large numbers of commuters enter and exit South Station during the commuter hours. Although observations show that pedestrians do have the tendency to cross the streets when vehicles have the right-of-way, this occurrence does not appear to occur at all intersections in the study area, particularly along the High Street and Franklin Street corridors. In these locations pedestrians do tend to cross the street on a "Don't Walk", however, relatively low dispersed vehicular volumes provide a sufficient number of gaps to allow them to cross. Other times when crossings occur on "Don't Walk" are when vehicle congestion has temporarily halted movement through the intersection. Although the effect of pedestrians on traffic flow varies by location, it has been accounted for later in the traffic flow analysis.

The existing pedestrian flow in the vicinity of the site is relatively light and can generally be accommodated by the sidewalk in the area. A pedestrian signal is currently located at the intersection of High Street, Oliver Street, and the High Street off-ramp and is currently used by pedestrians walking between the Fort Hill garage and their place of employment.

Finally, a pedestrian bridge crossing is located just south of the project site and in conjunction with pedestrian activated traffic signals, provide a safe crossing of Atlantic Avenue, the Central Artery, and Purchase Street. This bridge is used primarily by pedestrians walking between the Fort Point Channel and the Financial District.

C. FUTURE TRANSPORTATION NETWORK

Due to a variety of factors including current and projected land development, overall master planning concepts and the transportation needs of the area, there are several planned and proposed improvements to the entire transportation system. Many of these improvements are anticipated to be complete by 1990, the anticipated completion year for International Place. These improvement projects are discussed below, which form the basis of the 1990 No Build and Build transportation networks.

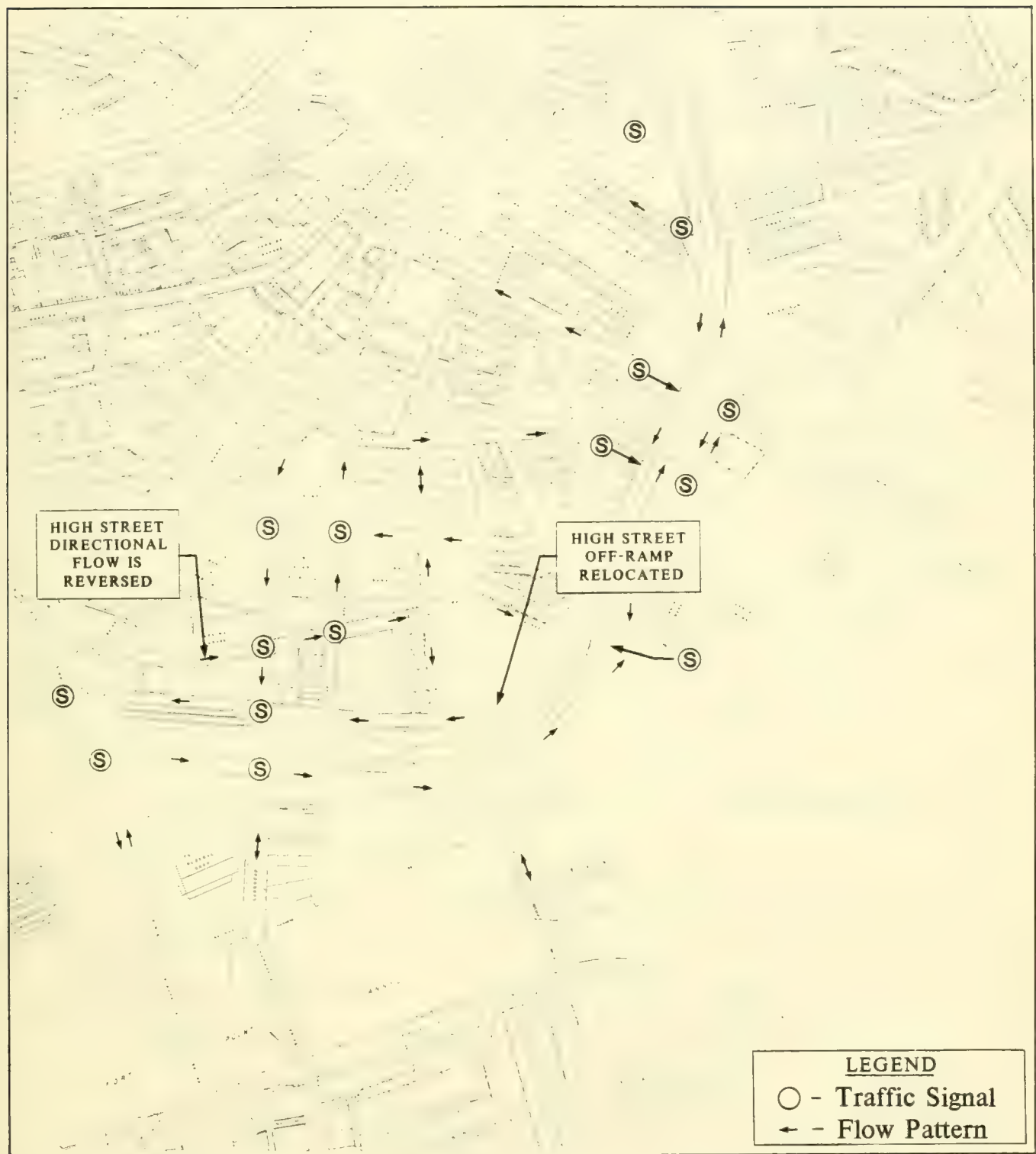
1. Highway

There are six different highway projects either in the planning or design stages which will potentially affect the travel patterns and demands within the study area. Table 12 lists these improvements while they are briefly discussed below. Figure 8 shows the traffic circulation pattern under anticipated 1990 conditions.

● Relocated Northern Avenue

This project is a bridge replacement project which currently proposes to realign Northern Avenue several hundred feet to the south of the existing bridge. The new bridge/roadway will consist of a multiple lane cross-section. The general curb to curb cross-section currently understood to be in design consists of two travel lanes per direction, two ten foot shoulders and a 16 foot median separating direction flow. In addition, traffic signal control will be provided at the Northern Avenue intersection with Atlantic Avenue.

Figure 8 - Future Study Area Traffic Flow Pattern



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TABLE 12
SUMMARY OF PLANNED MAJOR HIGHWAY IMPROVEMENTS

Project Name	Major Components
1. Northern Avenue Bridge Replacement	<ul style="list-style-type: none"> o New multi-lane bridge o Traffic Signal Northern Avenue/Atlantic Avenue
2. Dewey Square Transportation Improvement Program	<ul style="list-style-type: none"> o Traffic Circulation Changes o Reverse High Street flow direction to northbound o Exclusive express bus lane on arterials o Street closings o Improved Signal Coordination o Improved Pedestrian Crossings/Paths
3. South Station Transportation Center	<ul style="list-style-type: none"> o Direct highway link to major new parking facility (as part of major multi modal project)
4. Third Harbor Tunnel/Central Artery Project (post 1990)	<ul style="list-style-type: none"> o New tunnel between Mass. Turnpike/Southeast Expressway to Logan Airport o Added Capacity to highway o Reduction in on /off-ramps in Central Boston

● Dewey Square Transportation Management Systems Program

As previously discussed, a major planning study currently underway has studied a number of improvement alternatives for the Dewey Square area. Improvements include optimized and coordinated traffic signalization, a modification of traffic flow patterns (i.e. High Street travel direction reversed to northbound), and express bus priority treatment.

The reversal of High Street to northbound was proposed as part of a plan to emphasize Purchase Street as a major arterial in the

southbound direction. Reversing flow on High Street would force regional traffic exiting the Central Artery including trucks carrying hazardous materials to use Purchase Street. High Street would become more of a local street creating a more balanced one-way flow pattern between Franklin and Purchase Streets. In addition, with less volume on High Street, benefits to pedestrians within the Financial District would be realized.

As part of the Dewey Square planning study, traffic flow patterns with and without the ramp relocated were evaluated. It was concluded that for High Street to be reversed, it would be most desirable to relocate the existing off-ramp to Purchase Street.

● Third Harbor Tunnel/Central Artery Project

At the present time, this project is being vigorously pursued by the State, Regional and City officials. It will provide for a new four lane tunnel crossing from the Expressway/Turnpike to Logan Airport as well as adding a significant amount of capacity to the Central Artery. The project will also consist of reconstructing the interchange of the Massachusetts Turnpike, the Fitzgerald Expressway and the access into the South Station Transportation Center with one objective of directly connecting the regional highway system with a major parking facility.

Under this alternative, the existing relocated High Street off-ramp would be removed following completion of the Tunnel/Central

Artery project. However, a new off-ramp from the Central Artery in the southbound direction to Purchase Street would be constructed in its place.

If approved by the Federal Highway Administration, this project will take 10 to 15 years for completing construction. Because of its time for completion being beyond 1995, this transportation alternative was not included in the 1990 condition/analysis of this project as stated in the MEPA Scope.

2. Parking

There are several parking improvements or changes currently in the planning stages or being proposed within the vicinity of the project site. As discussed in detail in the comment/response section, major parking improvements to the public supply in the freeze area will require air quality studies and State/Federal concurrence prior to implementation. These various improvements are briefly described below.

● Post Office Square Garage

It is proposed to reconstruct the existing 950 space Post Office Square Garage and add approximately 500 parking spaces. It would be constructed completely underground with improved access/egress. Currently advancing through the State's environmental process, this project, if approved, is anticipated to be completed by 1990. Subsequent to the completion of the International Place DEIR, the Post Office Square project has completed its State environmental review process and no EIR was required.

● Rowes Wharf Development

In conjunction with the development of Rowes Wharf, 575 parking spaces are now to be provided of which 225 will be public parking spaces.

● South Station Area

As part of the South Station Transportation Center project, an 800 parking space garage is included in Phase I construction. In addition, it has been recommended that 2,200 additional spaces be provided in a structure with a direct link to the major highway network. The recent parking study^{1/} recommended to the City that certain adjustments to the City's parking freeze be made in order that parking needs in all areas of the City be met. (All changes to the freeze are recommended from the study are reprinted in the FEIR Appendix). This was strongly recommended in the South Station area due to its excellent proximity to both the regional highway network and the downtown area. Parkers could either walk or take public transportation (i.e., Red Line, buses) to reach their destinations.

For the purpose of this study, it has been assumed that the option to modify the freeze and create 3,000 parking spaces in total will be progressed since development which creates the transportation demands is continuing on a rapid pace. The transit

^{1/} Parking In Central Boston: Meeting the Access Needs of a Growing Downtown, Cambridge Systematics, Inc. with Vanasse/Hangen Associates, Inc., December, 1983.

system, although extensive and scheduled for improvements, cannot realistically meet the needs of all downtown employees and visitors. As a result, parking improvements will be necessary for the City to remain attractive to business and continue to grow.

● North Station Area

The parking study has also recommended increasing the supply of parking in the North Station area by 1,500. Again, good access to the regional network would be essential. Although located quite a distance from the International Place site, this facility could potentially result in a shift of parkers from parking facilities, which are convenient to the project site, to the new parking facility.

● Other Parking Modifications

In addition to the possible new supply of parking, recommended parking management actions have also been cited, some of which have been implemented. These include strict enforcement of on-street spaces to ensure proper use of the spaces and encourage space turn-over by including an expansion of parking meter control with appropriate rates.

3. Transit

As stated earlier in the report, the MBTA has improvement projects underway which will increase the capacity and improve the efficiency of all lines entering the downtown.

The transit element of the most recent Transportation Improvement Program (TIP) contains significant measures to upgrade the Massachusetts Bay Transportation Authority system during 1984 and continuing through 1988.

Generally, signal and communication improvements, plant improvements, park-and-ride programs, transit efficiency programs, and other system-wide measures are planned. These, as well as specific commuter rail, rapid transit, bus and commuter boat improvements will advance the restoration of existing facilities to good condition, broaden the service area, and increase system capacity and the level of service.

Major improvements to the rapid transit system include the Red Line extension from Harvard Street to Alewife Brook Parkway; the Orange Line Relocation Project in the southwest corridor; the Orange Line Service Replacement project; the Red Line station modernization; and the Blue Line track, power and electricity improvement projects. All of these projects will have significant effects on service capacity and level of service. Also, platform extensions to provide for six car trains and the procurement of additional rolling stock for the Red and Green Lines will help to serve the growing demand for mass transportation.

The South Station Transportation Center, located approximately 1,500 to 1,700 feet to the southeast of the site on Atlantic Avenue, represents a commitment to the strong need for the regional transportation function South Station has traditionally provided.

The Federal Railroad Administration is proposing improvements to South Station under the Northeast Corridor Improvement Project which includes the rehabilitation of the headhouse, reconstruction of the track areas, and the construction of new concourse. In addition, six levels of air rights above the track area will be developed by local agencies. The Phase I development by the Massachusetts Bay Transportation Authority of three air rights levels as a transportation center is planned to include an 800-space parking facility and a regional bus terminal. The Phase II development of the remaining three levels above the transportation center is being proposed by the Boston Redevelopment Authority and include 780,000 square feet of office and retail use, a 600-room hotel, a light industry complex, and a 1,700 space parking facility.

The following improvement projects are programmed through 1988 for specific modes and rapid transit lines.

Red Line

1. Signal and Communications Improvements
2. Kendall Station
 - station modernization
 - platform lengthening
 - traction power substation
 - elderly-handicapped accessibility
3. Track Improvements
 - rehabilitation of the new Red Line crossover at Park Street

4. Shawmut Tunnel Rehabilitation
5. Station Modernization
 - Station modernization and platform lengthening for six car trains
 - Ashmont
 - Washington Street
 - Park Street
 - South Station
 - Kendall
 - Central
 - Broadway
 - Platform lengthening only
 - Charles Street
 - Andrew
 - Savin Hill
 - Fields Corner
6. JFK/UMASS Station - to improve connection between Ashmont and Braintree lines and overall service connection.
7. Silverbird Rebuild Program
 - rehabilitation and modernization of 75 car Silverbird fleet
8. South Station Transportation Center
 - Commuter Rail/Rapid Transit direct connection
 - Intercity and commuter bus terminal
9. Acquisition of Additional Red Line Cars
 - 58 new cars for service to West Cambridge

10. Red Line Northwest Extension

- extension of rapid transit from Harvard Square to Alewife Brook Parkway
- 2,000 car parking garage at Alewife Station

11. Systemwide Electrification Improvement Program

Green Line

1. Signal and Communications Improvements
2. Track Improvements
3. Systemwide Electrification Improvement Program
4. Lechmere Station
 - relocated station
 - bus transfer facilities
 - work-train storage area
5. North Station Transportation Improvements Project
 - track realignment
 - station/complex integration
6. Procurement of 50 new light rail vehicles

Orange Line

1. Roxbury - South End Replacement Project
 - light rail or bus service after removal of existing evaluated structure/service as part of southwest corridor project
2. Wellington Station
 - 2,300 car parking garage

3. Orange Line Relocation

- rapid transit and commuter rail within same right-of-way
- New Stations
 - Back Bay
 - Massachusetts Avenue
 - Ruggles Street
 - Roxbury Crossing
 - Jackson Square
 - Boylston Street
 - Green Street
 - Forest Hills

4. Forest Hills to Needham Service

- replacement for discontinued Forest Hills to Needham commuter rail service

Blue Line

1. Signal and Communication Improvements

2. Power Improvements Project

- conversion of 25 Hz power system to 60 Hz system

3. Systemwide Electrification Improvement Program

4. Tunnel Rehabilitation

5. Station Modernization

- Suffolk Downs

6. North Shore Transit Improvements

- station improvements on commuter rail and transit lines
 - Salem
 - Lynn
 - Revere Beach

7. Bowdoin - Charles Connector

- Blue Line - Red Line, connection
- new Red Line station at Charles Street

Commuter Rail

1. Commuter Rail Improvement Program (Phase III)
 - Track, bridge, and signal improvements
2. Commuter Rail Improvement Program (Phase IV)
 - inspection and light maintenance facility for locomotive and coaches (south side)
 - bridge carrying the Eastern Routes over the Mystic River (north side)
 - rehabilitation of track on the Franklin Branch and Eastern Route
3. Commuter Rail Improvement Program (Phase V)
 - continuation of CRIP Program
4. Reconstruction of Budd Cars
 - conversion of 93 Budd Cars from self-propelled units to commuter rail coaches
5. Acquisition of new rail cars

Bus

1. West/Northwest Bus Garage
 - new and more efficient facility housing 200 buses
2. Arborway Garage
 - new multi-purpose maintenance reducing facility for 200-250 buses
3. Rehabilitation of 80 Buses and Purchase of 100 Buses

Commuter Boat

1. Commuter Boats
 - procurement of two commuter boats
2. Construction of Hingham Passenger Terminal with Parking Facility
3. Improved Ferry Terminal in Conjunction with Rowes Wharf Project

Although the current year Transportation Improvement Program lists many projects to be completed by 1990, it is recognized that many improvements will extend beyond 1990. It is important to note, however, that improvements to stations, rails, signal systems, and rolling stock are currently well underway. The consequences of these improvements will certainly improve reliability and increase line capacity. The Orange Line relocation and the Red Line extension are expected to be completed by 1986-1987. New rolling stock is expected over the next two years for both Red and Green lines. The following section describes the existing and anticipated rolling stock for both subway, commuter rail, and bus systems.

● Rolling Stock

To provide scheduled service, the MBTA requires fleet sizes greater than the demand for peak period service. For various reasons, many vehicles on a given day will not be suitable for the day's service. In Table 13, existing fleet sizes are shown for rapid transit, commuter rail and bus operations. The required number of vehicles for scheduled service ranges from 60 to 70 percent of the existing fleet with the exception of the Green Line. On the Green Line, substantially fewer vehicles are used than the stated 275 vehicle fleet and this is due to the particularly severe problems with Boeing build LRVs. When the LRVs are not considered part of the fleet, the required vehicles-to-fleet size ratio stated above is also valid for the Green Line.

TABLE 13
ROLLING STOCK INVENTORY

Line	Existing Fleet	Increase by 1988	Future Fleet
Red	164	58	222
Green	275	50	325
Orange	120	0	120
Blue	70	0	70
Commuter Rail	122 ^{1/}	36	158
Bus	1,049	N.A. ^{2/}	1,100

^{1/} This represents passenger carrying vehicles only.

^{2/} The MBTA proposes to purchase, repair and retire buses for the next few years and beyond in order to develop a future active fleet of 1,100 buses. Presently, there are 1,220 buses in the fleet, however, 1,049 are active.

Future purchases of 58 new Red Line vehicles will enable service to the Alewife Station extension. Fifty new Green Line cars which are to be delivered prior to 1990 (expected 1985-1986 delivery) were purchased to partially relieve the present LRV problems.

The rebuilding of vehicles is also scheduled for the next five years. The 76-car Silverbird Fleet on the Red Line will be rebuilt and the 98 BUDD Rail Diesel cars will be converted from self locomotion of passenger carrying functioning only. The Green Line LRVs are also planned for rebuilding however this will likely occur further in the future.

Bus fleet maintenance and development involves a programmed 100 vehicle purchase for the next few years as well as some rebuilding and attrition which will provide for an active 1,100 bus fleet.

4. Pedestrians

Several pedestrian improvements have been recommended in the vicinity of the project site. These include minor improvements in pedestrian signal timing at many of the intersections, as well as more major projects.

One major improvement presented in the Dewey Square planning study includes a new pedestrian bridge crossing from Atlantic Avenue to Purchase Street. This would be located approximately 100 feet south of the existing bridge crossing. A positive aspect of this improvement is that two pedestrian-actuated signals will be eliminated (on Atlantic Avenue and on Purchase Street) as well as

the potential conflicts which currently occurs between pedestrians and vehicles at these two locations. Traffic flow will also be positively impacted as through vehicles on either street will not be delayed due to the signal.

The other improvement is related to the Rowes Wharf Project. This project consists of installing a pedestrian-actuated traffic signal to provide for safe crossing from the east side of Atlantic Avenue to the existing island in front of Rowes Wharf. Pedestrian and vehicular volumes are currently uncontrolled at this location and result in a generally unsafe condition. This would complete the series of pedestrian crossings providing walking access from Atlantic Avenue to High Street. The proponent of Rowes Wharf is committed to the improvement (paving, landscaping, and potentially lighting) of this crossing area and is working with the City towards the installation of this recommended signalized pedestrian crossing.

D. HIGH STREET SOUTHBOUND OFF-RAMP RELOCATION

The idea of relocating the High Street southbound off-ramp is not new or unique to the proposed development project. Both the City, through the BRA Dewey Square Transportation Systems Management (TSM) Study, and the State, to some degree, in the Third Harbor Tunnel/Central Artery Study, have studied this transportation alternative.

As mentioned, the relocation project would move the southbound off-ramp terminal from High Street to Purchase Street. In conjunction with this, Oliver Street would be designated as one-way east-bound toward Purchase Street preventing vehicles coming off the ramp from turning right and crossing the Purchase Street through traffic. Also under this proposal, High Street would become one-way north-bound from Summer Street to the Surface Artery. The reversal of High Street has been a major modification studied as part of the Dewey Square planning project.

The Dewey Square transportation planning study found that by reversing the traffic flow on High Street from its current south-bound direction to northbound, positive impacts would occur from a traffic circulation perspective in this area of the Financial District. The study also found that only by relocating the off-ramp did the reversal work most effectively. This study also showed that with both the High Street off-ramp relocated and the traffic flow pattern reversed, an improved pedestrian atmosphere would prevail along the High Street corridor connecting it with the remaining areas of the Financial District.

The Third Harbor Tunnel/Central Artery EIS studied the overall ramp connection system to the Central Artery and the preferred Tunnel/Artery alternative involves limiting the numbers of on- and off-ramps. The preferred alternative concept also indicates that the southbound off-ramp to High Street would be deleted and in its place, a Purchase Street southbound off-ramp constructed.

As discussed in the response section, design studies were completed and show that even if the Central Artery Depression project is advanced to construction, a temporary relocation rather than permanent relocation of the High Street off-ramp is possible. In fact, the preliminary design of ramp relocation completed in May, 1984 specifically took into account how the Artery would be depressed. It was engineered in a manner that Artery reconstruction can take place with minimal impact on the ramp operations, even during slurry wall construction. The design of the project as a whole has been sensitive to both the ramp relocation and Artery depression. At the completion of the Depressed Artery, the temporary ramp could be dismantled. Subsequent to the DEIR public comment period, design issues with respect to the Depressed Artery have surfaced which may have an effect on the timing of the relocation project. Consequences of this are discussed in the comment/response section.

Since several major transportation studies for this particular area have considered the High Street off-ramp be relocated, the analysis in this EIR concentrates primarily under that assumption. However, the consequences on travel patterns in the area as a result of International Place if the ramp is not relocated have been qualitatively assessed and described later in this report.

ALTERNATIVES TO THE PROJECT

TRANSPORTATION

The alternatives to the project from a traffic analysis point of view are the Build and the No-Build alternative. As described earlier in the report, the Build alternative includes 1.8 million square feet of floor space. These project alternatives as well as the transportation network included as part of the analysis alternatives are described in the following paragraphs.

A. NO-BUILD

In compliance with MEPA guidelines a No-Build alternative was examined to establish baseline traffic conditions. The incremental impacts of the proposed project may be determined by making comparisons to the No-Build alternative. The No-Build alternative assumes that the project is not built. Under this alternative, traffic increases along study area roadways would be associated with normal traffic growth patterns as well as other currently planned development projects.

Projects which are anticipated to be completed and occupied by 1990 are to be included in the No-Build alternative. As discussed in more detail later in this report and in the comment/response section, the No-Build networks relied largely on the 1990 projections completed for the Third Harbor Tunnel/Central Artery Environmental Impact Study. Generally, projects outlined in the MEPA Scope were included in those projections.

B. BUILD

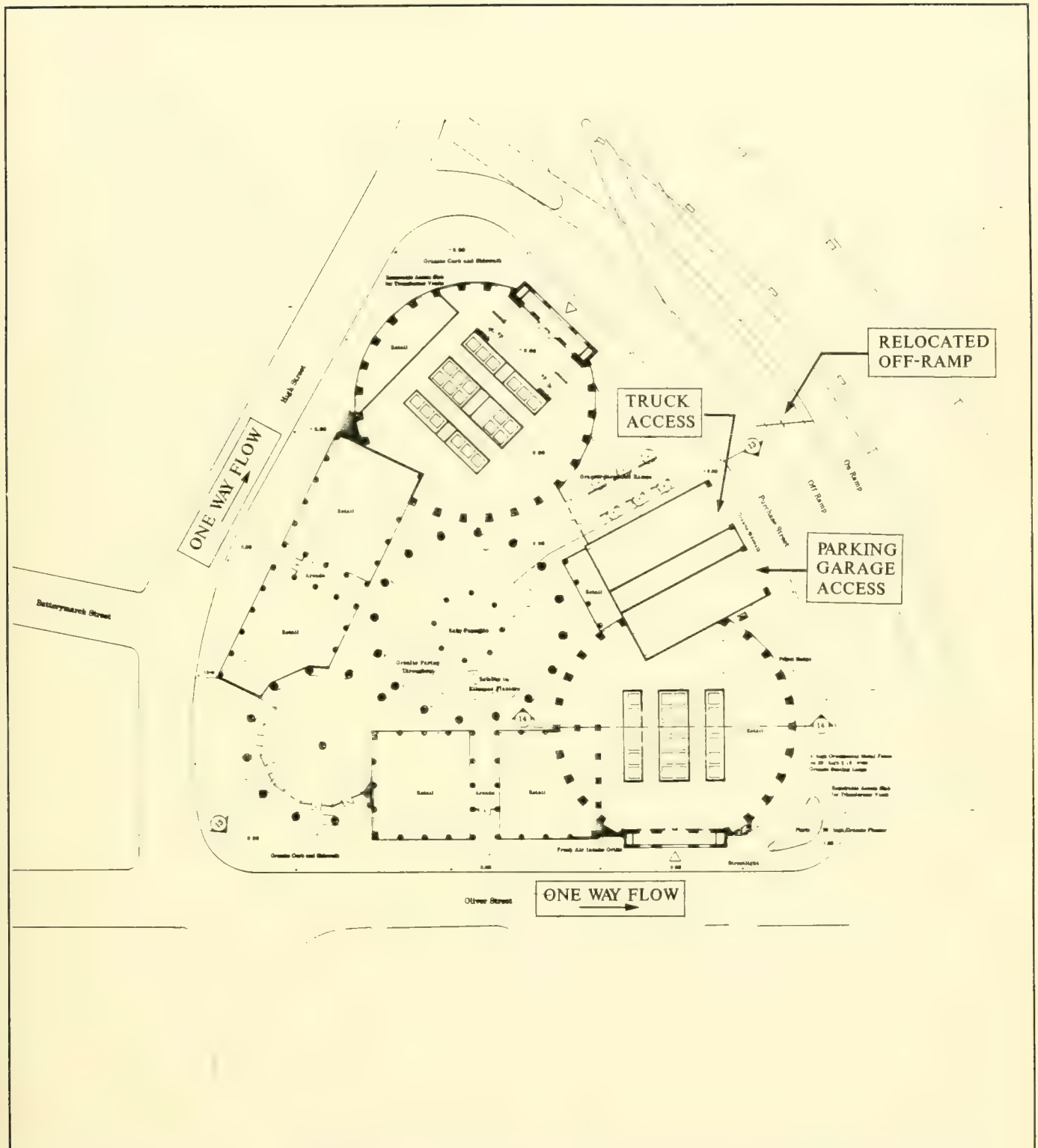
The Build alternative consists of the full development of 1.8 million square feet of floor space by 1990 and includes a 827-space parking garage. As previously described, the site is bounded by High Street, Purchase Street, and Oliver Street. Access into and out of the 827 space parking garage to be built as part of the project as well as truck docks would be off of Purchase Street. Figure 9 illustrates the ground level site plan and access points.

TABLE 14
NO-BUILD BACKGROUND DEVELOPMENT PROJECTS

Project	Type of Development
Piers 1, 2 and 3	Mixed Use Development
Boston Marine Industrial Park	Warehouse/Industrial Uses
Commonwealth Pier 5	High Tech Marketing Center
Dewey Square Tower	Office Use
Building 114 South Boston Army Base	Mixed Use
Rowes Wharf	Mixed Use
260 Franklin Street	Office Use
265 Franklin Street	Office Use
Market Place Center	Office/Retail Use
53 State Street (Exchange Place)	Office Use

Of the total floor space, 1.7 million square feet will contain office space while the remaining 100,000 square feet will be devoted to retail and commercial space (i.e. restaurants).

International Place at Fort Hill



Under this build alternative, it is proposed that the south-bound High Street off-ramp from the Central Artery would be moved from its current location, touching down on High Street at the Oliver Street intersection, to Purchase Street touching down just north of Oliver Street as shown in concept in Figure 9. Traffic accessing the site from the north on the Central Artery would now exit onto Purchase Street, turn right onto Pearl, then right on High Street to Purchase Street, north of the site, right again on Purchase Street to enter the garage.

PROBABLE IMPACTS OF THE PROJECT

TRANSPORTATION

The focus of this section is to identify the probable impacts of International Place on the surrounding transportation system. Included in this section is a description of the future No-Build traffic flow conditions, an estimate of International Place travel characteristics and an assessment of the transportation impacts that may be created by the project.

A. BACKGROUND TRAFFIC GROWTH

Growth in transportation demands is a function of expected land development in the region. Projecting this growth can be done in several manners including the application of a growth factor to base traffic conditions, the assessment of site specific developments if known, and finally system level projections based on employment and population data.

The 1990 No-Build network was developed using a combination of these methods. It was largely based on information and projections developed during the Third Harbor Tunnel/Central Artery EIS, the Dewey Square TSM Planning Study. Other recent environmental reports completed for projects located within the general study areas provided additional information which was used to refine the network. The overall procedure in developing the 1990 No Build networks is discussed in detail in the comment/response section. In addition, since the No Build networks were largely based on Third

Harbor crossing (THC) studies, an excerpt from the EIS which describes the traffic forecasts methodology used in that study is also included in this FEIR appendix. Background growth projects included in that project are shown in Table 15. As can be seen, by reviewing the table, the ten development projects to be included in this project as required by the MEPA scope have been included in the THC study. Table 16 illustrates a more disaggregated estimate of the ten projects trip impact on the regional network.

Based on this effort, the 1990 AM and PM No-Build volume networks were developed and are shown in Figures 10 and 11.

B. FUTURE PROJECT TRAVEL DEMANDS

To estimate the impact of International Place on the transportation system in the study area, several sources of information were used. These included the preliminary traffic impact appraisal completed in February for International Place, the Copley Place DEIR Supplement, the Dewey Square Tower EIR, survey data obtained by the BRA, and the recent City Parking study data. This information was also utilized in preparing the International Place EIR completed for the BRA earlier this year. Details of transportation surveys of the employees who were located in close proximity to the project site provided an invaluable resource of actual mode split and auto occupancy data for the project employees. Summaries of this information are included in the FEIR appendix and discussed in detail in the comments/response section.

TABLE 15
MAJOR LAND USES (FUTURE) USED IN
THIRD HARBOR TUNNEL/CENTRAL ARTERY
ENVIRONMENTAL IMPACT STATEMENT

Table 59 MAJOR LAND USES IN THE PROJECT AREA			
SOUTH BOSTON (See Figure 1)			
Existing Uses			
1. Dockside Place (condominiums)	2. Temporary housing for Navy personnel	3. Commercial buildings	4. 100 Congress Street (offices)
5. Stone & Webster Engineering Corporation (offices)	6. Neptune Lobster Company	7. Anthony's Pier & Restaurant, Piers 4-5	8. Fish Pier
9. Pier Grill	10. Fargo Building (U.S. Government offices)	11. McEneaney Lighter Company	12. The Gillette Company (Industrial)
13. Mixed-use industrial area	14. Lindenmeyer Paper Company	15. Boston Plate and Window Glass	16. New England Seafood Center
17. Paul's Lobster Company, Stavio	18. Sealord	19. Royer, Inc. (manufacturing)	20. Harding Company (manufacturing)
21. Pier Transmission	22. Boston Harbor Industrial Park	23. Boston Marine Terminal	24. Boston Tea Party Ship Museum
25. Children's Museum	26. One Lady of Good Voyage Chapel	27. U.S. Post Office parking	28. COMAIL Street
29. South Boston Army Base			
Future Uses			
30. Northern Avenue Bridge	31. Former Post Central Parcel (offices)	32. Boston Wharf properties (offices, residential)	

FINANCIAL DISTRICT (See Figure 8)			
Existing Uses			
1. Devonshire Towers (residential)	2. Blue Cross/Blue Shield Building (offices)	3. 155 Federal Street (offices)	4. Prudential Trust Building (offices)
5. Traveler's Bus Station	6. Keybank Building (offices)	7. High Street Garage	8. New England Telephone (offices)
9. Western Union Building (offices)	10. The Travelers' Building (offices)	11. State Street Bank Building (offices)	12. Wadsworth Hotel
13. Batterymarch Building (offices)	14. 80 Broad Street (offices)	15. Small mixed-use buildings	16. Grain Exchange (offices)
17. Wharf buildings (offices)	18. 40 Broad Street (offices)	19. 33 Broad Street (offices)	20. One Liberty Square (offices tower)
21. 55 State Street (offices tower)	22. 40 State Street (offices tower)	23. Downtown Crossing (Films'ns, etc.)	24. Shawmut Bank Building (offices)
25. 81 Anthony's Shrine	26. MTA Operations Center	27. Fort Mill Place Station	28. Fort Mill Garage
29. John McCormack U.S. Post Office and Court House	30. McGill Memorial Park	31. Kilby Street Garage	

NORTH BOSTON (See Figure 8)			
Existing Uses			
1. Harbor Towers (condominiums)	2. Waterfront Wharf Apartments	3. Chatham Square (offices)	4. Aurora Apartments (elderly housing)
5. North End Community Nursing Home	6. Fenwick Hall Market Place	7. Bostonian Hotel	8. Baymarket (open air market)
9. Long Wharf Marriott Hotel	10. New England Aquarium		
Future Uses			
11. Parcel D-10 (retail, offices)	12. Blackstone Block rehabilitation (retail, offices)	13. Sargent's Wharf (residential)	14. MTA Powerhouse (residential)

GOVERNMENT CENTER (See Figure 8)			
Existing Uses			
1. Bank of New England Building (offices)	2. Commercial office buildings	3. State Crescent (offices)	4. New England Telephone - Downtown Square Building (offices)
5. Jewish Social Services Building	6. Boston City Hall	7. Veterans' Administration	8. Outpatient Clinic
9. City Hall Plaza			
Future Uses			
13. Waterfront Terraces (residential)			

NORTH STATION (See Figure 8)			
Existing Uses			
1. Boston Garden	2. Anson Building (offices)	3. Atlantic Lobster building	4. Hoffman building (offices)

WEST END (See Figure 8)			
Existing Uses			
1. Any Lovell House (elderly housing)	2. Charles River Park (residential)	3. The Blackstone (elderly housing)	4. Holiday Inn
5. Charles River Plaza (retail)	6. 30 Standford Street (offices)	7. Massachusetts Bay and Bay Railway	
Future Uses			
21. MBTA Substation	22. Parking Garage	23. Office Building	24. New Area
25. Mainland development site, MA	26. Sub-area 11 (hotel, retail)	27. Canal and Island development site, MA	28. Relocated MBTA Green Line and Computer Rail Facilities
Future Uses			
18. Government Services Administration Federal Building	19. MBTA Electric Substation	20. Charles River Dam and Locks	
Future Uses			
21. MBTA Substation	22. Parking Garage	23. Office Building	24. New Area
25. Mainland development site, MA	26. Sub-area 11 (hotel, retail)	27. Canal and Island development site, MA	28. Relocated MBTA Green Line and Computer Rail Facilities

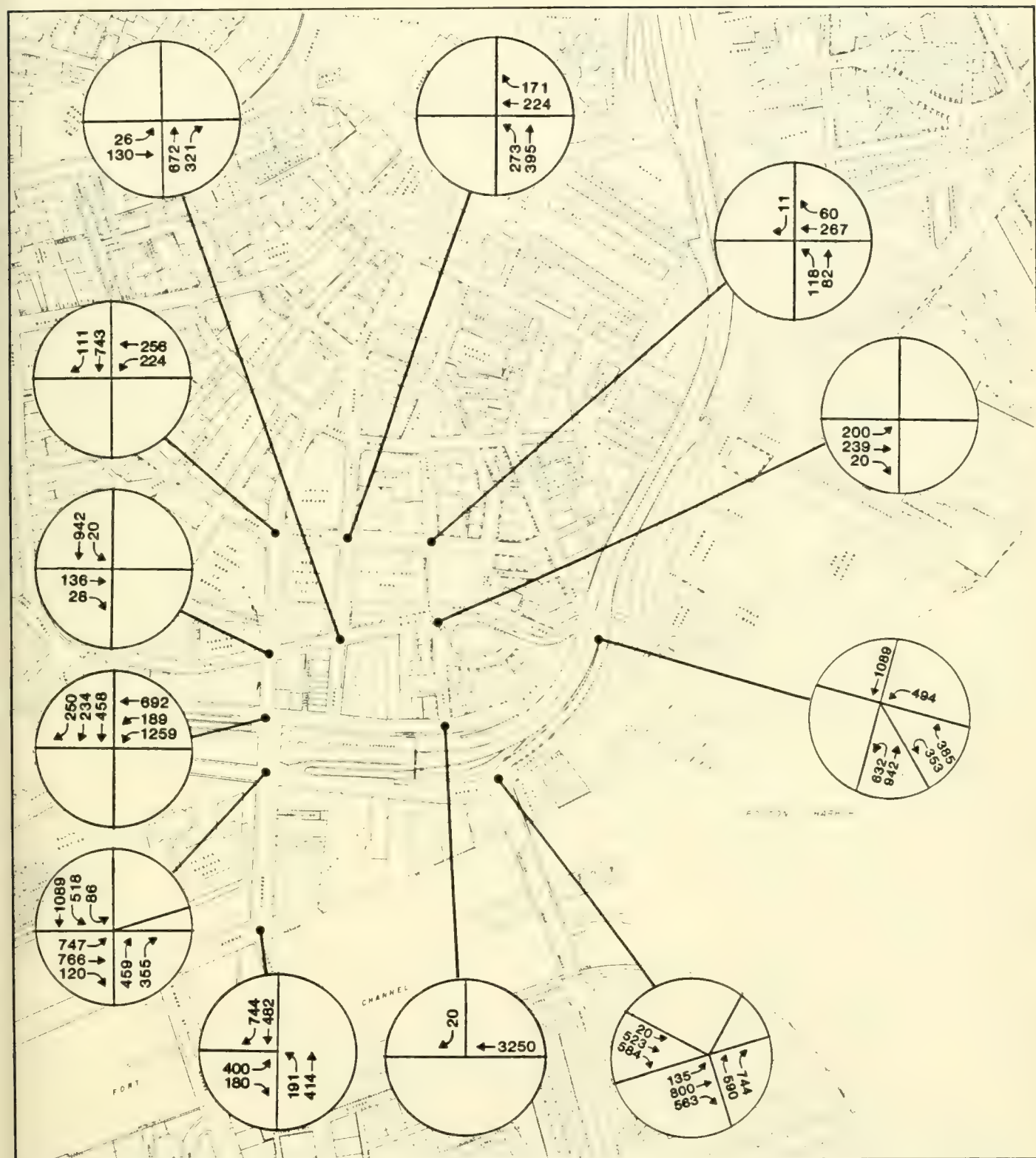
SOUTH BOSTON (See Figure 1)			
Existing Uses			
1. U.S. Power Factory Store	2. Remondino's Italian Restaurant	3. Jody's Auto Village	4. Francis, Rose and Company
5. Suffolk County Jail			
Future Uses			
9. New England State Prison (warehouse)	10. Kean's Antique Building (manufacturing)	11. Stop and Shop Bakery	12. Charles River Park parcel (future use unknown)
13. Charles River Building (manufacturing, offices)	14. Boston Edison Steam Plant	15. Massachusetts Rehabilitation Hospital	16. Mass. Registry of Motor Vehicles/Dept. of Public Works
17. MBTA helicopter pad	18. North Station Computer Rail Terminal	19. Government Services Administration Federal Building	20. MBTA Electric Substation
21. Charles River Dam and Locks			
Future Uses			
21. MBTA Substation	22. Parking Garage	23. Office Building	24. New Area
25. Mainland development site, MA	26. Sub-area 11 (hotel, retail)	27. Canal and Island development site, MA	28. Relocated MBTA Green Line and Computer Rail Facilities

SOUTH BOSTON (See Figure 1)			
Existing Uses			
1. Dockside Place (condominiums)	2. Temporary housing for Navy personnel	3. Commercial buildings	4. 100 Congress Street (offices)
5. Stone & Webster Engineering Corporation (offices)	6. Neptune Lobster Company	7. Anthony's Pier & Restaurant, Piers 4-5	8. Fish Pier
9. Pier Grill	10. Fargo Building (U.S. Government offices)	11. McEneaney Lighter Company	12. The Gillette Company (Industrial)
13. Mixed-use industrial area	14. Lindenmeyer Paper Company	15. Boston Plate and Window Glass	16. New England Seafood Center
17. Paul's Lobster Company, Stavio	18. Sealord	19. Royer, Inc. (manufacturing)	20. Harding Company (manufacturing)
21. Pier Transmission	22. Boston Harbor Industrial Park	23. Boston Marine Terminal	24. Boston Tea Party Ship Museum
25. Children's Museum	26. One Lady of Good Voyage Chapel	27. U.S. Post Office parking	28. COMAIL Street
29. South Boston Army Base			
Future Uses			
30. Northern Avenue Bridge	31. Former Post Central Parcel (offices)	32. Boston Wharf properties (offices, residential)	

TABLE 16
TRIP CHARACTERISTICS OF SPECIFIC BACKGROUND DEVELOPMENT PROJECT

Project	Size	Time Frame	Type	Source	Daily Vehicle-Trips	AM			PM		
						In	Out	Total	In	Out	Total
260 Franklin Street	345,000 S.F.	1985	Office	Cabot, Cabot & Forbes	1,162	232	0	232	0	232	232
265 Franklin Street	370,000 S.F.	1984-85	Office/Retail	Ryan Elliott	1,248	250	0	250	0	250	250
Dewey Square Tower	1,031,285 S.F.	1984	Office/Retail	Draft EIR dated Oct. 80 by HMM Assoc.	850	389	0	389	0	389	389
Building 114	1,650,000 S.F.	1987	Garment Center/ Office/Industrial/ Warehouse	Building 114 DEIR by VHA dated Dec. 82	5,734	428	80	508	93	411	504
Marketplace Center	442,084 S.F.	1987	Office/Retail Museum	FEIR by Sasaki Assoc. April, 83	1,059	283	0	283	16	327	343
Comm. Pier Five	1,311,000 S.F.	1987	Mix Use/BOSCOM	FEIR by SOM, VHA, dated September, 82	2,350	308	8	316	75	254	329
Rowes Wharf	665,000 S.F.	1987	Mix Use	FEIR dated July, 82	2,780	185	69	254	114	183	297
53 State Street	1,186,000 S.F.	1984	Office Use	Excerpt from Traffic Study completed for BRA	2,140	751	0	751	0	751	751
Piers 1, 2 & 3	325,000 S.F. 1,000 Rm. Hotel 900 Dwelling Unit 50 Berths Marina	1990	Mix Use	Comm. Pier Five FEIR	14,270	501	0	501	15	480	495
Boston Marine Industrial Park	350,000 S.F.	1987	Industrial/	Comm. Pier Five FEIR	1,858	203	68	271	106	319	425

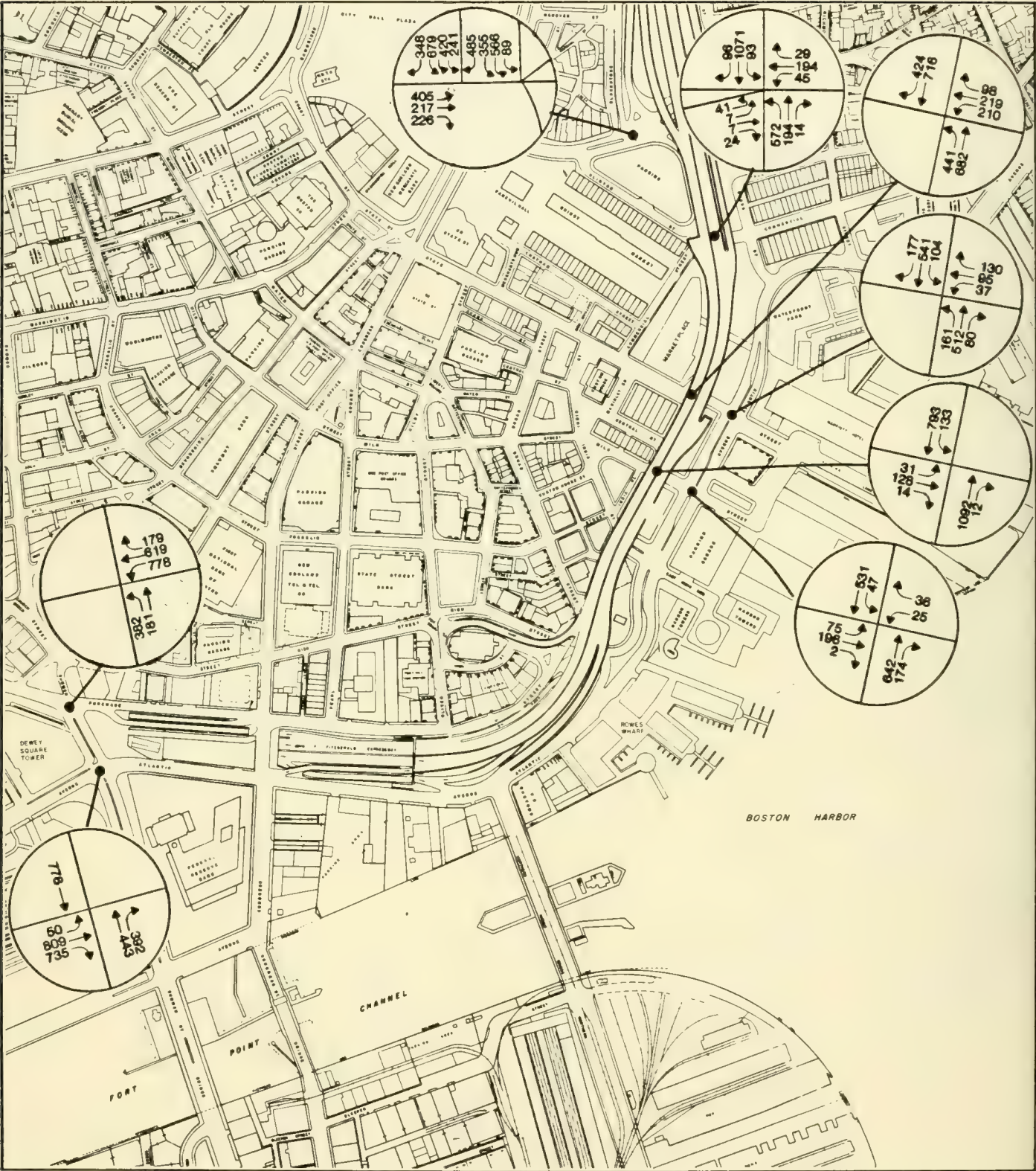
Figure 10a - 1990 AM No Build Network



International
Place
at Fort Hill

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Boston, MA

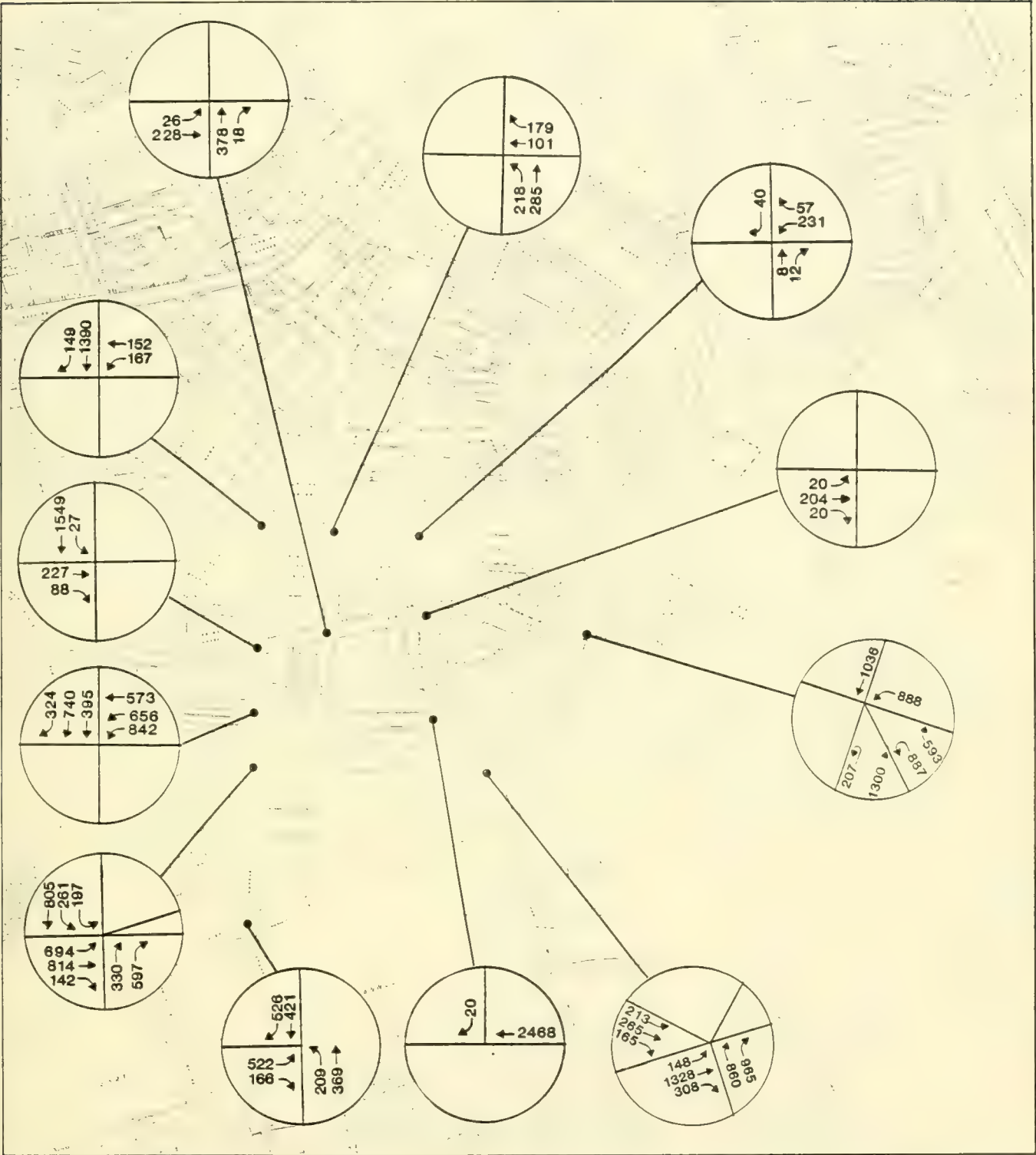
Figure 10b - 1990 AM No Build Network



International
Place
at Fort Hill

Vanasse/Hangen Associates
Boston, MA

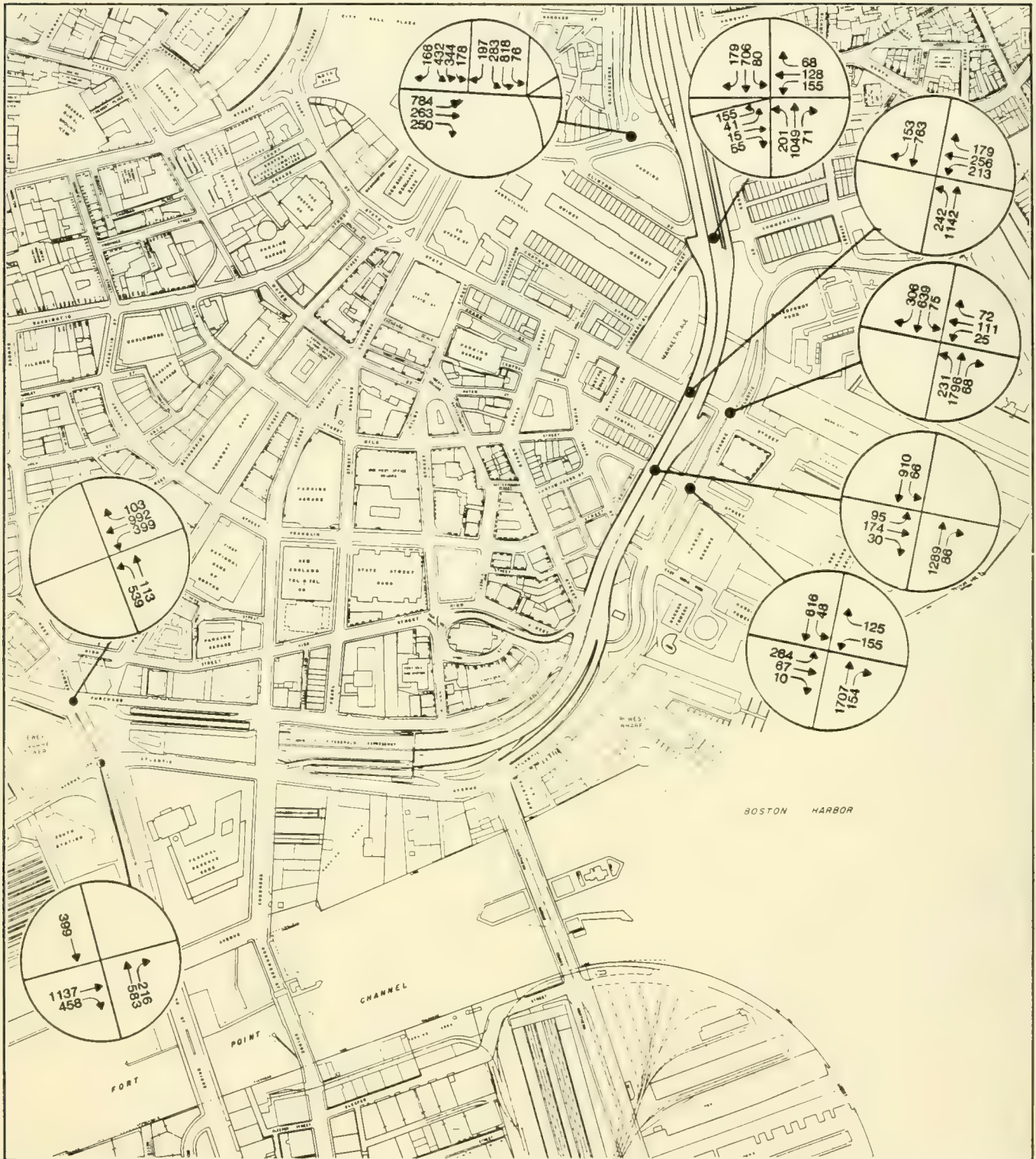
Figure 11a -1990 PM No Build Network



International
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at Fort Hill

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Figure 11b - 1990 PM No Build Network



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1. Person Trip Generation

In order to accurately assess the impact of the project on the transportation system in the study area, separate travel demand estimates by type of use and user were made. The procedures used in estimating person-trips and vehicle-trips consisted of initially calculating person-trips per 1,000 square feet of floor space. The trips were categorized by office vs. retail and work vs. non-work. By applying mode split percentages and auto occupancy factors to the person-trips, the estimated number of vehicle-trips can be determined. Finally, based on 1982 Boston cordon survey data, person-trips by transit were further broken down by type of transit.

Tables 17, 18 and 19 summarize person-trip rates, mode split percentages and auto occupancy rates used in the analysis. The values shown in the tables are based on data from actual surveys, and previous studies including the downtown parking study. Table 17 represents a total person count entering and exiting per 1,000 square feet of building over the course of the day independent of mode of arrival at the project.

TABLE 17
PERSON-TRIP GENERATION RATES

Use	User	Daily Person Trips/1,000 SF		
		In	Out	Total
Office	Work	4.40	4.40	8.80
	Non-work	2.35	2.35	4.70
	Total	6.75	6.75	13.50
Retail	Work	2.75	2.75	5.50
	Non-work	16.40	16.40	32.80
	Total	19.15	19.15	38.30

The work trip rates reflect expected employment density in the proposed project and are typically employee arrival and departure trips. Non-work trips are trips made to and from the project for all other purposes (i.e. shopping, outside business, lunch, etc.).

Table 18 summarizes the mode of arrival characteristics assumed for the project. These percentages were derived from actual survey data and analysis indicated in previous studies including the Copley Place EIR and the Boston parking study. The mode split characteristics in Table 17 were applied to the total trip estimates to determine trips by transportation mode. As discussed in the comments/response section of this report, surveys completed in both 1972 and 1980 verify the use of transit and private auto into the city and financial district, in particular.

TABLE 18
MODE SPLIT PERCENTAGES

Use	User	Percent Trips By		
		Auto	Transit	Walk
Office	Work	30.0	70.0	0
	Non-Work	27.5	57.5	15
Retail	Work	30.0	70.0	0
	Non-Work	27.5	32.5	40

Table 19 summarizes anticipated vehicle occupancy rates (VOR) for those trips arriving by auto. Again, the rates were primarily based on actual surveys of area employees. The average auto occupancy for office work trips is 1.8 persons per auto while the non-work trip VOR is 1.4 persons per auto.

TABLE 19
VEHICLE OCCUPANCY FACTORS

Trip Type	Use	
	Office	Retail
Work	1.8	1.4
Non-work	1.4	1.9

o Daily Person-Trips Estimate

The rates described in the previous subsection were applied to the proposed office and retail floor space of the International Place development to obtain the anticipated travel demands. The site will contain approximately 1,700,000 square feet of office space and 100,000 square feet of retail floor space.

Table 20 summarizes the total daily person trip estimate for the project. As can be seen, a total of 26,780 new person-trips are anticipated to be generated at full buildout of the project over the course of the day representing 13,390 person-trips entering and 13,390 person-trips exiting.

TABLE 20
INTERNATIONAL PLACE
DAILY NEW PERSON-TRIP ESTIMATE

Use	Trip Type	In	Out	Total
Office	Work	7,480	7,480	14,960
	Non-work	3,995	3,995	7,990
Retail	Work	275	275	550
	Non-work	<u>1,640</u>	<u>1,640</u>	<u>3,280</u>
		13,390	13,390	26,780

2. Mode of Arrival

Table 21 summarizes the mode of arrival of these trips. Multiplying the trip estimate in Table 20 by the mode split factors in Table 18 results in approximately 71 percent of the person trips accessing the project by a mode other than private auto. Only 29 percent of the trips to the site are expected by personal auto while approximately 62 percent are expected by transit. The remaining 9 percent are walk trips. Due to the characteristics of the International Place project which consists of 100,000 square feet of retail type space, the actual number of person-trips made by auto may in fact be less than shown. It is expected that the major portion of the retail or commercial space (i.e. supply shop, card shop, restaurant) would primarily serve the office complex and not attract, in itself, a large number of vehicle-trips. Rather, the retail-related walk trips would far exceed both the transit and auto trips. However, the mode split percentages indicated in Table 18 were used and the result is a somewhat more conservative analysis.

TABLE 21
1990 INTERNATIONAL PLACE
DAILY NEW PERSON-TRIPS BY MODE
(Total In and Out)

Use	Trip Type	All Vehicle Modes	Transit	Walk
Office	Work	4,488	10,472	0
	Non-work	2,198	4,594	1,198
Retail	Work	165	385	0
	Non-work	902	1,066	1,312
Total		7,752	16,518	2,510

1/ Taxis and deliveries are present in existing vehicular flow.

3. Peak Hour Person-Trips

Of greater concern than the daily trips is the portion of those trips occurring during the peak commuter hours. It is these peak periods which are used to judge the performance of the transportation system. Tables 23 and 24 present a summary of the trips occurring during the morning and afternoon peak periods and were derived by multiplying one-half of the daily person-trips (to reflect directional travel) by the appropriate factors in Table 22. As can be seen, approximately 17-18 percent of the total daily trips are expected to occur during each of the peak hours.

TABLE 22
PERCENTAGES OF INTERNATIONAL PLACE DAILY TRIPS
DURING PEAK HOURS AND OFF-PEAK HOURS

	Work			Non-work		
	AM Peak	PM Peak	Off- Peak	AM Peak	PM Peak	Off- Peak
Office						
Arrivals	55	0	2	10	0	15
Departures	0	55	2	0	10	15
Retail						
Arrivals	10	10	12	0	5	10
Departures	0	20	12	0	10	10

Source: HMM Associates, Inc., Copley Place Draft EIR
Supplement/Draft EIS, 1980, Table 7.4-3.

TABLE 23
1990 INTERNATIONAL PLACE AM PEAK HOUR
PERSON-TRIPS BY MODE

	All Auto Modes	Transit	Walk
Office			
Work	1,234	2,880	0
Non-work	110	230	60
Retail			
Work	8	20	0
Non-work	0	0	0
Total	1,352	3,130	60

TABLE 24
1990 INTERNATIONAL PLACE PM PEAK HOUR
PERSON-TRIPS BY MODE

	All Auto Modes	Transit	Walk
Office			
Work	1,234	2,880	0
Non-work	110	230	60
Retail			
Work	25	58	0
Non-work	68	80	98
Total	1,437	3,248	158

4. Vehicle Trip Generation

Perhaps of greatest concern to the proponent and the city is the impact of the project on traffic flow. By applying the auto occupancy rates in Table 19 to the daily and peak hour estimates of person trips by auto, the number of vehicle trips to and from the project site can be estimated. These estimates are shown in Table 25. At full development the project will generate approximately 770 auto-trips during the morning peak hour while 819 auto-trips will be generated during the evening peak hour.

TABLE 25
1990 VEHICLE TRIPS GENERATED BY
INTERNATIONAL PLACE DEVELOPMENT
(In and Out)

	Daily	AM Peak	PM Peak
Office			
Work	2,494	685	686
Non-work	1,570	79	79
Retail			
Work	118	6	18
Non-work	474	0	36
Total	4,656	770	819

The total number of daily vehicle trips include employee related trips, visitors, taxis, and delivery vehicles. Peak hour trips to and from an office building normally consist of employee related trips only and do not normally include a significant number of taxi trips or delivery service vehicles. Commuter trips by taxi in Boston have been observed to represent 0.2 percent of the total commuting trips. The taxi and delivery vehicle trip daily estimates are described in the following paragraphs.

● Taxi Trip Generation

The characteristics of the proposed International Place project and the transportation condition in the vicinity of the project will result in a certain amount of taxi related travel. Taxi trip generation was estimated based on a national research project^{1/} which included surveying office buildings and observing the actual number of taxi trips to and from the building.

^{1/} Highway Research Board, NCHRP Report No. 62, Urban Travel Patterns For Hospitals, Universities, Office Buildings, and Capitols, 1969.

It should be recognized that there is not a substantial amount of data available which can be used to estimate taxi trip generation. The method outlined above presents a reasonable method based on substantial research. It was estimated that for every 100 person-trips, there will be 1.5 trips made by taxi. This results in an estimated 400 taxi trips over the course of the day including 200 destined for the site and 200 leaving the site.

Consequently, there will be a need for designated taxi stands near the site. Currently, a major taxi holding area is located on Franklin Street near Oliver Street. However, it would be appropriate to designate some curbspace, on both High Street and Oliver Street for passenger loading and unloading. To accommodate the estimated number of taxi trips, the length of curb designated for taxi should be long enough for five vehicles, approximately 100 feet.

This estimating procedure does, however, vary somewhat from that used in the Marketplace Center EIR study which stated that "3 percent of office non-employee arrivals by auto were taxi passengers or were dropped off by drivers who proceeded elsewhere." Using this 3 percent factor for this project would result in approximately 120 taxi trips including arrivals and departures. This is much lower than the 400 taxi trips estimated above and used in this analysis.

● Delivery Vehicle Generation

Delivery and maintenance vehicles generated by the site will consist of both light and medium duty trucks. Heavy duty trucks will also be required (i.e. for trash pick-up and occasionally for major deliveries of office furniture). However, most of those vehicles are expected to arrive at off-peak hours or during times when little additional traffic is competing for access to the area. Although the daily flow of maintenance and delivery vehicles will vary between individual buildings, it is estimated that approximately 200 to 225 light trucks and delivery trucks will serve the International Place building complex each day. This estimate is based on research recently conducted by the Polytechnic Institute of New York^{1/}. As part of this research effort, delivery service vehicle activity was observed in various cities across the United States, including downtown Boston. The estimate of truck/delivery service vehicles to be generated by International Place was verified through detailed field observations in downtown which indicated a delivery vehicle generation rate of about 0.25 per 1,000 square feet.

These deliveries vary in size, packages, and duration. A large number of the deliveries and pickups will consist of courier service in which automobiles or small vans are used. Also, mail deliveries, supply trucks for office and retail establishments, trash pick-up,

^{1/} Polytechnic Institute of New York, Curbside Pick-Up and Delivery Operations and Arterial Traffic Impacts, Prepared for Federal Highway Administration, February, 1981.

and food service are all included in the estimate. Due to the project's downtown location, some of the courier service may in fact be done on foot or bicycle, thus reducing the number of projected delivery vehicles.

Delivery and loading dock facilities for International Place will be located entirely off-street in an underground garage with access from Purchase Street only. Although many deliveries will utilize the off-street loading facilities, small type deliveries or pick-ups such as courier service and mail service will tend to park on-street. Similar to taxis it will be necessary to designate curbspace to accommodate some delivery/pickup activity.

Delivery and maintenance vehicles are not expected to contribute to local street congestion since access to the off-street underground loading dock will be off Purchase Street while curbside loading will occur on either High Street or Oliver Street which will experience relatively light vehicular traffic.

In addition, most delivery activity will occur during off-peak hours. It has been shown^{1/} that 85 to 90 percent of pick-up and delivery activity to office buildings occur during off-peak travel hours between 9:00 AM and 4:00 PM. Also average dwell time for deliveries has been estimated to be approximately 20 minutes.

^{1/} Polytechnic Institute of New York, Curbside Pick-Up and Delivery Operations and Arterial Traffic Impacts, Prepared for Federal Highway Administration, February, 1981.

5. Trip Distribution

The generated vehicle-trips and transit trips which have been discussed in this section with respect to the International Place development project were then distributed over the transportation system. This distribution was based on data available in the Copley Place EIR and the Dewey Square Office Building EIR which were derived from regional information on travel patterns. Table 26 Trip Distribution Summary, illustrates the magnitude of the directional distribution. These percentages were then applied to trips by each mode, adjusted if a corridor was not served by a particular mode.

TABLE 26
TRIP DISTRIBUTION SUMMARY^{1/2/}

<u>Corridor^{3/}</u>	<u>Work Trip</u>	<u>Non- Work Trip</u>
Northeast	14%	14%
North	14%	10%
Northwest	9%	10%
West	17%	16%
Southwest	22%	22%
Southeast	<u>24%</u>	<u>28%</u>
Total	100%	100%

-
- ^{1/} Copley Place Draft EIR Supplement/
Draft EIR.
^{2/} Dewey Square Office Building Draft
Environmental Impact Report.
^{3/} Corridor is in relation to downtown
Boston.

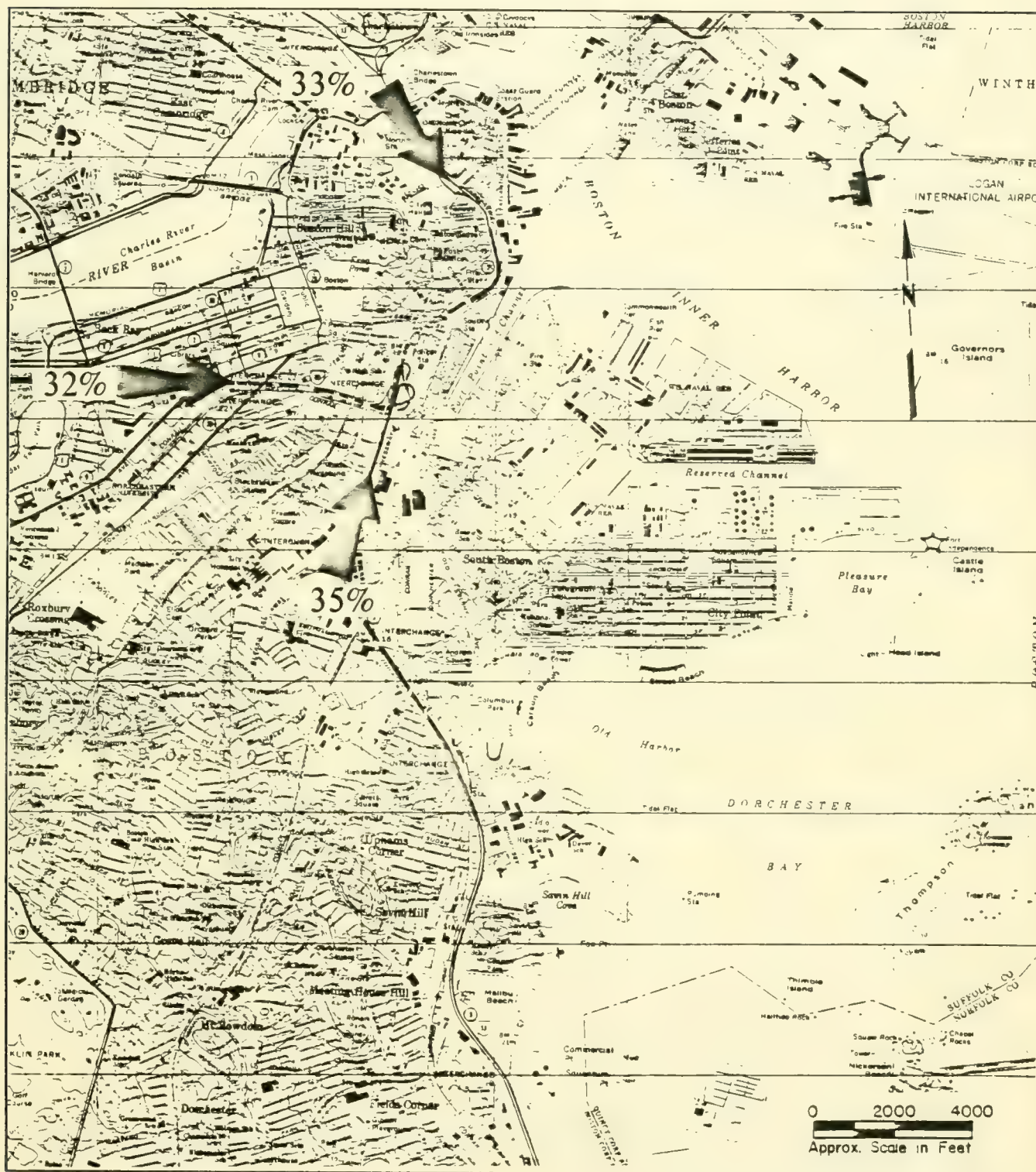
Figure 12a illustrates the general regional trip distribution pattern of vehicular trips generated by the project. As can be seen, it is split relatively evenly with approximately 33 percent using the Central Artery from the north, 32 percent from the west along the Massachusetts Turnpike and 35 percent from the south along the Southeast Expressway.

Based on the trip distribution patterns indicated, vehicle and transit trips were assigned to the highway and transit networks. Information from the previously identified reports as well as data from the 1982 Boston Cordon count provided the basis for assigning transit trips among subway, commuter rail and express bus lines. The results are presented in the next section of the report.

C. 1990 BUILD TRAFFIC VOLUMES

The vehicle trips generated by the International Place development were assigned to the network using the trip distribution percentages presented previously and superimposed upon the projected 1990 No-Build traffic volumes. Assignment to the local street system was based on the anticipated 1990 traffic flow patterns, the anticipated highway improvements, and the location of available parking with respect to the regional highway access and egress ramps. Major parking areas assumed to accommodate motorists related to the International Place development included the South Station garage (3,000 spaces assumed), the Post Office Square Garage (1,450 spaces), the Aquarium Garage (1,150 public spaces, the Rowes Wharf garage (225 public spaces) and the 827 space garage included with

Figure 12a - Regional Trip Distribution to International Place



International
Place
at Fort Hill

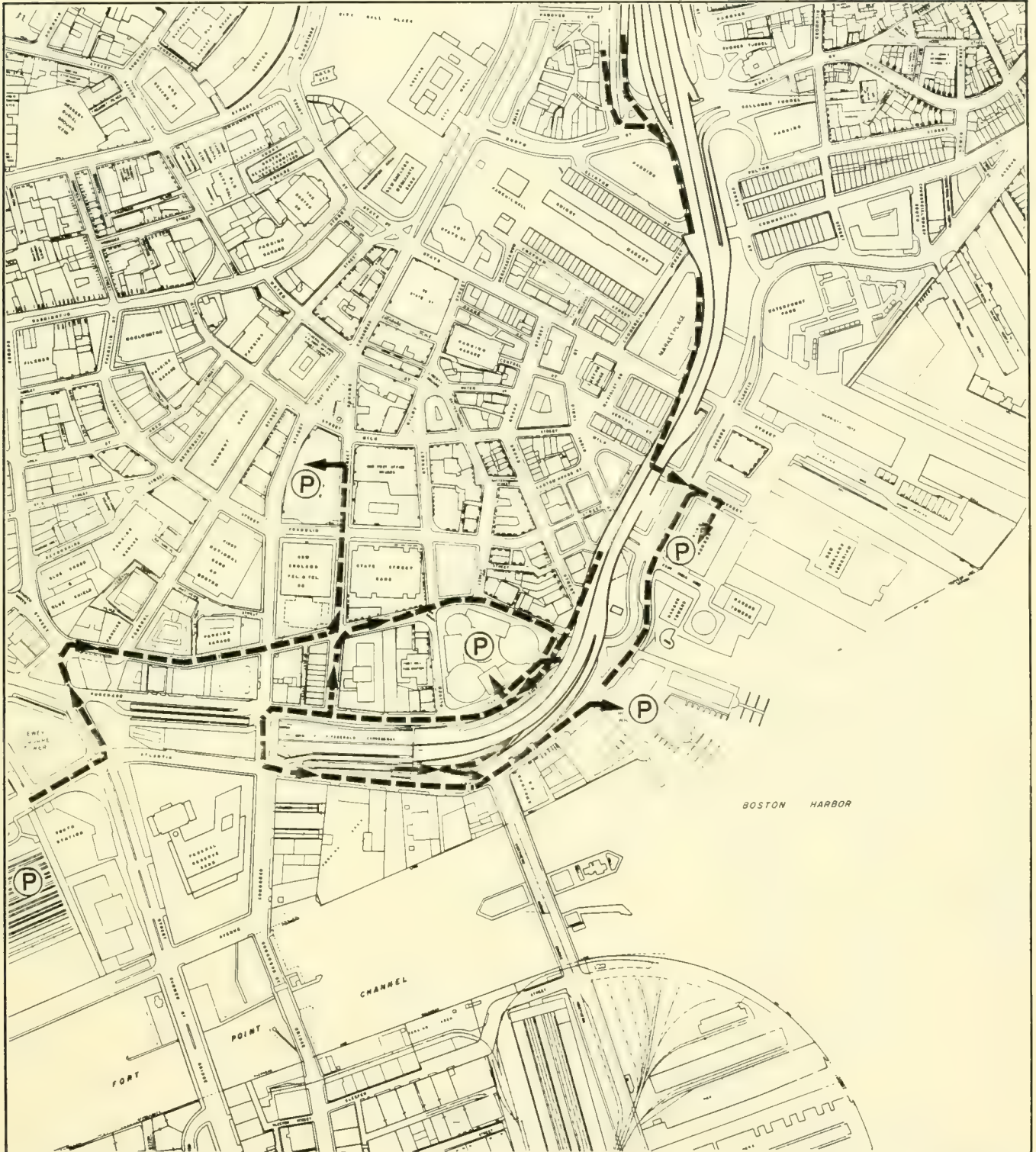
Vanasse/Hangen Associates
Boston, MA

the project. New vehicle-trips were assigned proportionally to these areas. In proportioning the site traffic to specific facilities, it was assumed that two-thirds of the site garage would be used as long-term parking. The results of the computation indicated a peak hour distribution to these facilities of approximately 50 percent to site garage, 30 percent to the South Station complex, 7 percent to both Post Office Square and the Aquarium garage, and 5 percent to the Rowes Wharf Garage. Access routes to and from these facilities to the regional highway network is shown in Figures 12b and 12c.

Figures 13 and 14 show the projected traffic volume networks under the Build condition.

Table 27 shows the anticipated changes in volumes on selected streets in the study area with and without the project. Also shown in the table are conditions with the project and without the south-bound off-ramp being relocated. The next section discusses the implications of the off-ramp in more detail. As would be expected, most of the impact is going to be felt on Purchase Street and the Surface Artery as the on- and off-ramps to the Expressway and Turnpike are accessed from them. However, the actual impact on these streets and other downtown arterials serving the project as a result of the project related trips are anticipated to be minimal for several reasons including the spatial location of the various parking facilities which would be used by employees and visitors to the complex.

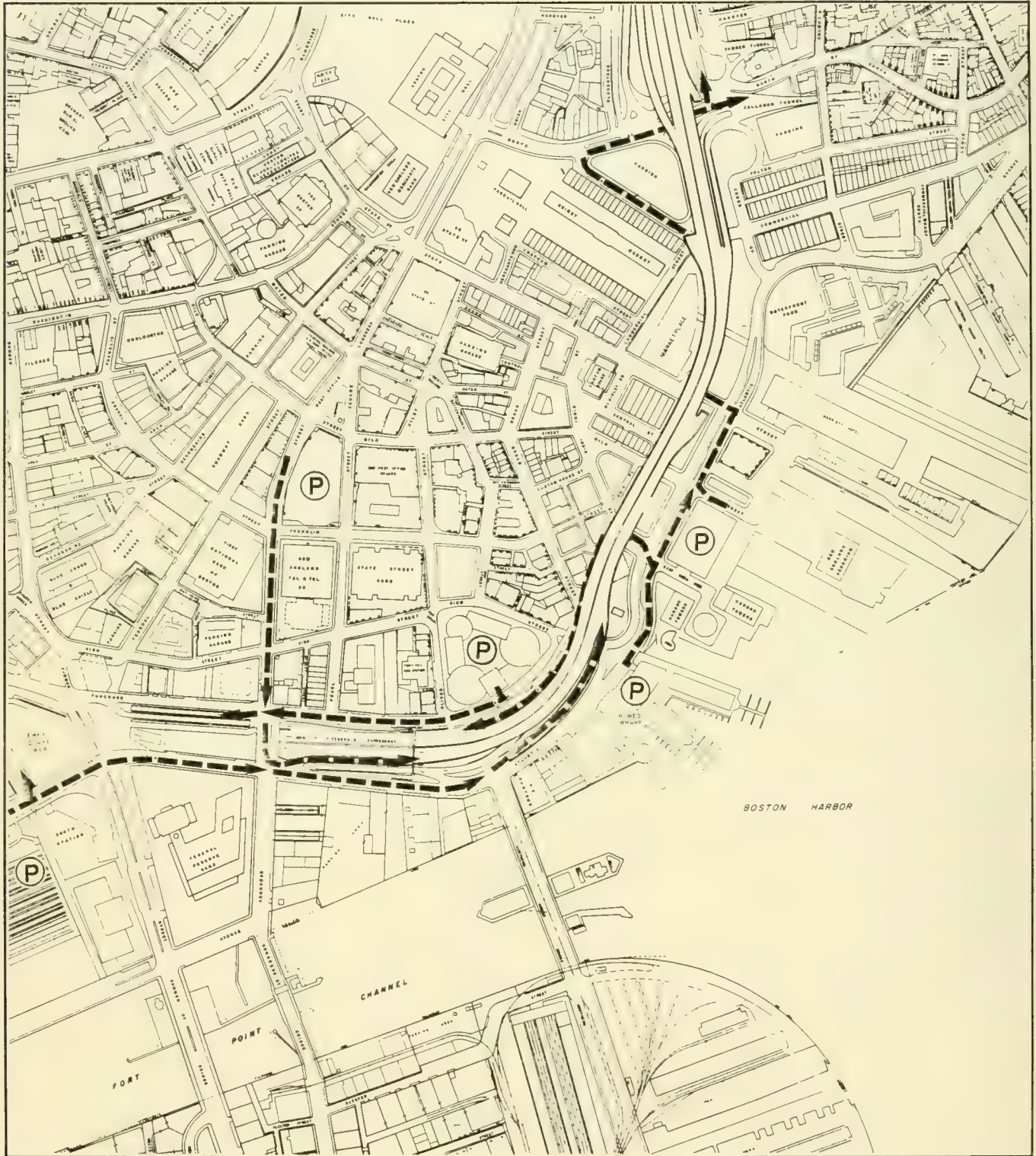
Figure 12b - Vehicle Access Routings From Central Artery



International Place at Fort Hill

Vanasse/Hangen Associates
Boston, MA

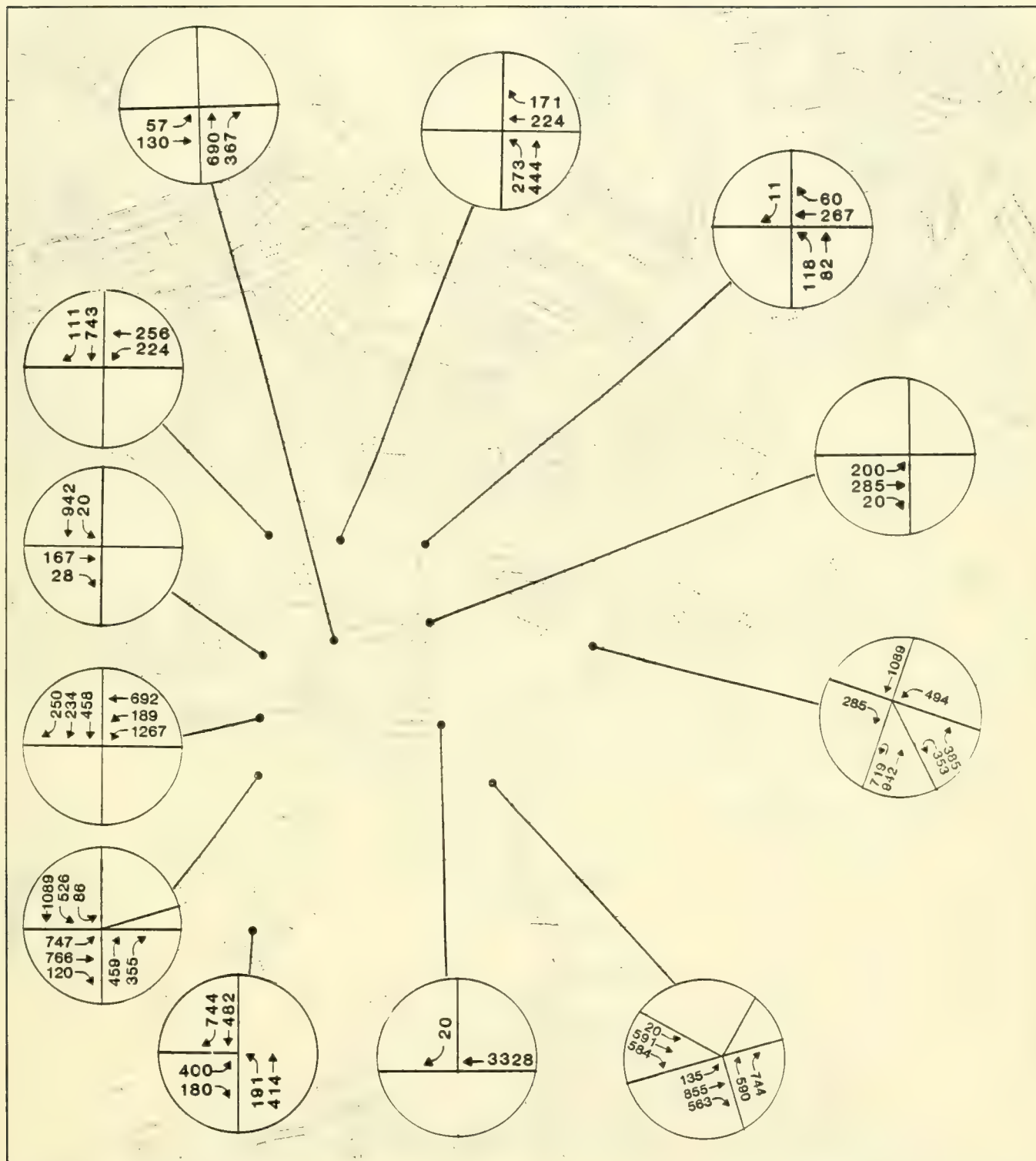
Figure 12c - Vehicle Access Routings to Central Artery



International
Place
at Fort Hill

Vanasse/Hangen Associates
Boston, MA

Figure 13a - 1990 AM Build Network



International
Place
at Fort Hill

Vanasse/Hangen Associates
Boston, MA

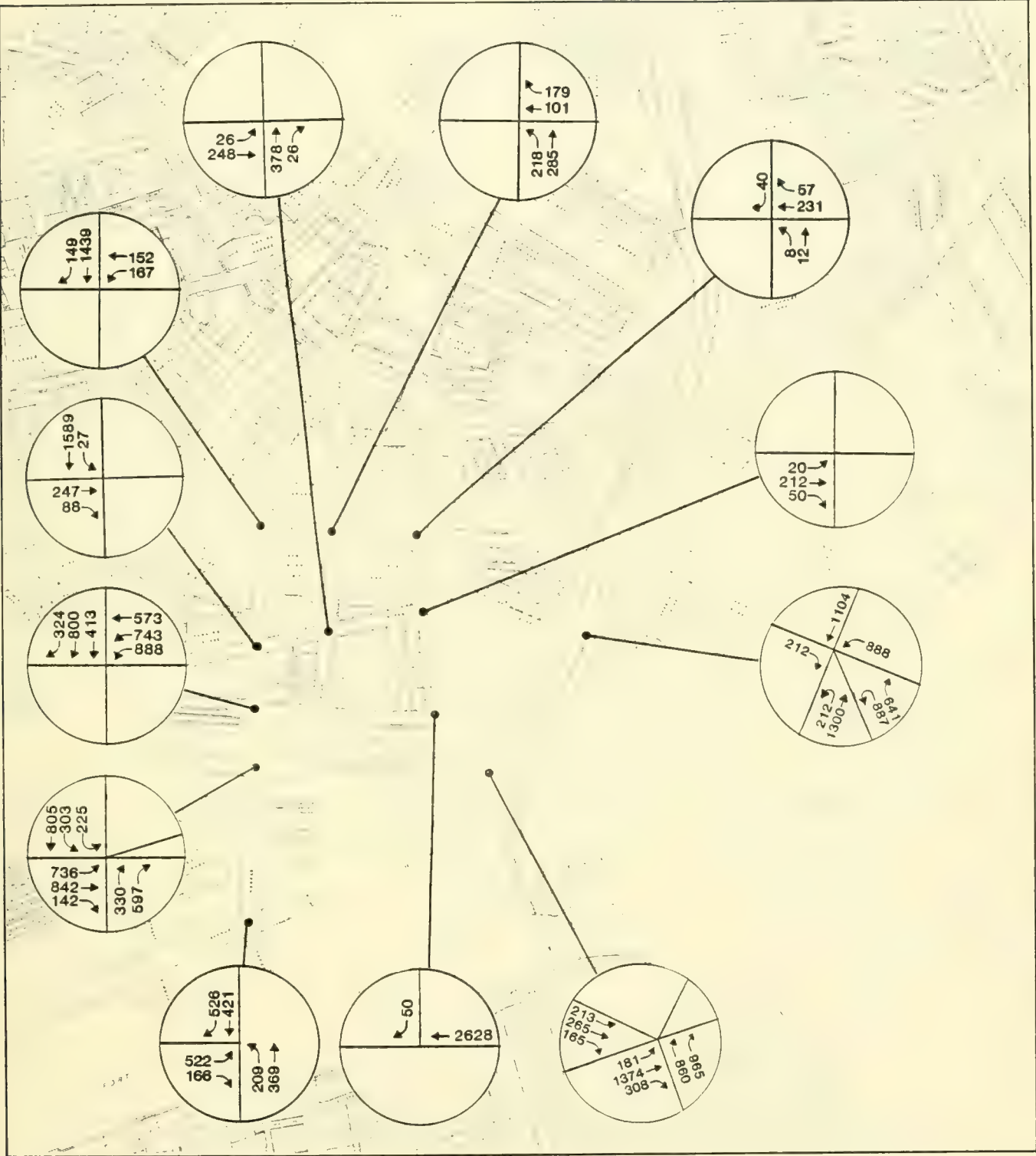
Figure 13b - 1990 AM Build Network



International
Place
at Fort Hill

Vanasse/Hangen Associates
Boston, MA

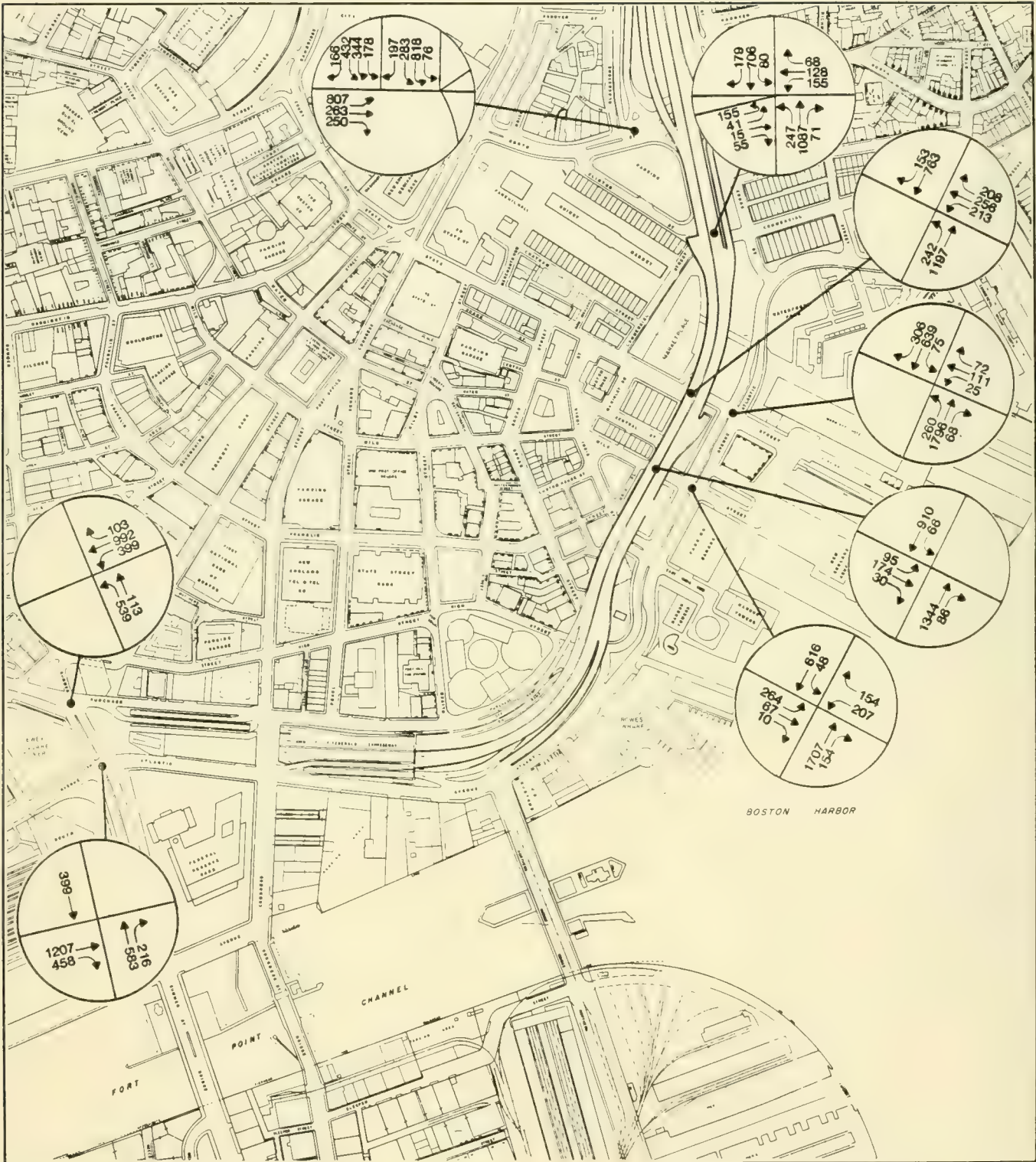
Figure 14a - 1990 PM Build Network



International
Place
at Fort Hill

Vanasse/Hangen Associates
Boston, MA

Figure 14b - 1990 PM Build Network



International
Place
at Fort Hill

Vanasse/Hangen Associates
Boston, MA

As determined in the initial traffic planning work for this project, the noticeable changes in traffic volumes indicated in Table 27 are primarily due to the changes in the regional access/egress system. For example, the existing High Street off-ramp has been relocated to Purchase Street under both 1990 networks. This results in approximately 1,400 to 1,500 vehicles added to Purchase Street during the morning peak hour and 600 to 700 during the evening peak hour. Traffic which used High Street under the existing network will now use Purchase Street.

The net increase in traffic volumes on Purchase Street due to the project are anticipated to be approximately 70 to 80 vehicles during the morning peak hour and 125 to 160 during the evening peak hour. These increases represent approximately a 3 to 4 percent increase over traffic volumes with the network modifications but without the project.

The final design features of Purchase Street and the relocated off-ramp should be sufficient to accommodate the diverted traffic volumes as well as the additional traffic as a result of the project. As discussed in the next section, the signalized intersections rather than the roadway links control the operating conditions of the study area network.

Other streets which will experience small increases in traffic flow due to the project include Atlantic Avenue, High Street, Congress Street and the Surface Artery. The impact varies

TABLE 27
SUMMARY OF PEAK HOUR VOLUME COMPARISONS

	1990 No-Build With Ramp Relocation		1990 Build With Ramp Relocation		1990 No-Build Without Ramp Relocation		1990 Build Without Ramp Relocation	
	AM	PM	AM	PM	AM	PM	AM	PM
<u>Purchase Street</u>								
North of Oliver St.	3,250	2,468	3,328	2,628	923	1,217	923	1,277
North of Congress St.	2,140	2,071	2,148	2,204	1,417	1,421	1,447	1,560
South of Congress St.	942	897	942	897	366	478	366	478
<u>Atlantic Avenue</u>								
North of Congress St.	1,639	1,672	1,647	1,742	1,647	1,672	1,647	1,742
North of Northern Ave.	2,067	2,558	2,190	2,604	2,122	2,268	2,190	2,314
North of Milk St.	1,331	2,760	1,345	2,789	1,331	2,760	1,349	2,778
<u>High Street</u>								
North of Congress St.	156	254	187	274	721	650	721	650
North of Oliver St.	239	204	285	212	919	696	968	696
<u>Congress Street</u>								
East of High St.	970	1,637	970	1,677	1,087	1,780	1,087	1,820
<u>Pearl Street</u>								
East of High St.	993	396	1,057	404	54	31	54	31
<u>Franklin Street</u>								
South of Pearl St.	480	319	480	319	480	319	480	319
<u>Surface Artery</u>								
North of State St.	1,920	2,237	1,935	2,321	1,920	2,237	2,078	2,321
North of High St.	2,416	2,929	2,416	3,045	2,416	2,929	2,554	3,045

depending on peak period. The increases on these streets are largely due to the location of available parking and travel route between the parking facility and the Central Artery.

Pearl Street between Purchase Street and High Street, will be affected by the change in traffic flow patterns due to the relocated ramp rather than by the project. With High Street reversed, and Oliver Street one-way eastbound, Pearl Street between Purchase and High Streets will carry a substantial amount of diverted traffic. Motorists who formerly used High Street to get to Pearl Street or Oliver Street will be forced under the build alternatives to use Purchase Street before turning right onto Pearl Street. North of High Street, No-Build and Build traffic volumes on Pearl Street are comparable.

D. TRAFFIC FLOW IMPACT WITHOUT RAMP RELOCATION

Assuming that International Place goes forward and the High Street southbound off-ramp is not relocated, there will be some differences in circulation patterns in and around the site. However, as discussed below, the changes in circulation will be relatively minor when compared to the anticipated network which includes the ramp relocated to Purchase Street.

If the ramp is left in place, traffic using the ramp to access the garage will have to use a different local access pattern, however, regional travel patterns will not change. It is important to point out that only inbound trips coming from the north will be

affected by this ramp relocation issue. The remaining inbound trips from the south and all outbound trips will use the same circulation pattern from the parking facilities to the artery whether or not the ramp is relocated.

● Patterns with Ramp Relocation

In order to understand the project related travel patterns if the southbound off-ramp is not relocated, a review of flow patterns with the relocation is provided. As shown in later sections of this report, relocating the High Street off-ramp and reversing High Street will shift a relatively significant volume of traffic from High Street to Purchase Street, particularly during the morning peak hour as inbound trips are made. Peak hour volumes along High Street will become relatively light. Motorists destined for the International Place garage, the Post Office Square garage or parking facilities (if available) across the Fort Point Channel will use the relocated off-ramp to Purchase Street. Currently, motorists wishing to park across the channel and traveling from the north exit off the High Street ramp and travel to Purchase Street via Oliver Street. Relocating the ramp only gets these motorists to Purchase Street more directly. Motorists who currently use High Street to reach Post Office Square via Pearl or Franklin Streets would now use Purchase Street to Pearl Street and eventually Post Office Square.

Trips to/from the South and West would continue to exit and enter the Central Artery at existing on and off-ramps. All of those who exit the northbound Central Artery destined for High Street would likely turn onto Purchase Street when High Street is reversed. However, those motorists traveling into the Post Office Square area have a second routing option which consists of continuing on the Surface Artery to Broad or State Streets and eventually the Post Office Square area. The latter routing requires motorists to travel through a series of traffic signals which will add to the overall travel time, making this routing less attractive. A worst case analysis consists of shifting all motorists who currently turn onto High Street southbound onto Purchase Street after the direction of High Street is reversed.

● Traffic Patterns Without High Street Southbound Ramp Relocated

If the High Street southbound off-ramp is not relocated, it is highly unlikely that traffic flow direction on High Street will be reversed. Without the reversal of High Street, motorists who currently turn up High Street from either the Central Artery, Surface Artery, or Atlantic Avenue will continue to do so in the future. The consequence of this is that traffic volumes on Purchase Street would be lower compared to the relocation alternative. Access to the Post Office Square or the Fort Point Channel area would not change from current conditions. Motorists from the South and destined for the International Place garage would still turn onto Purchase Street from the Central Artery High Street northbound off-ramp.

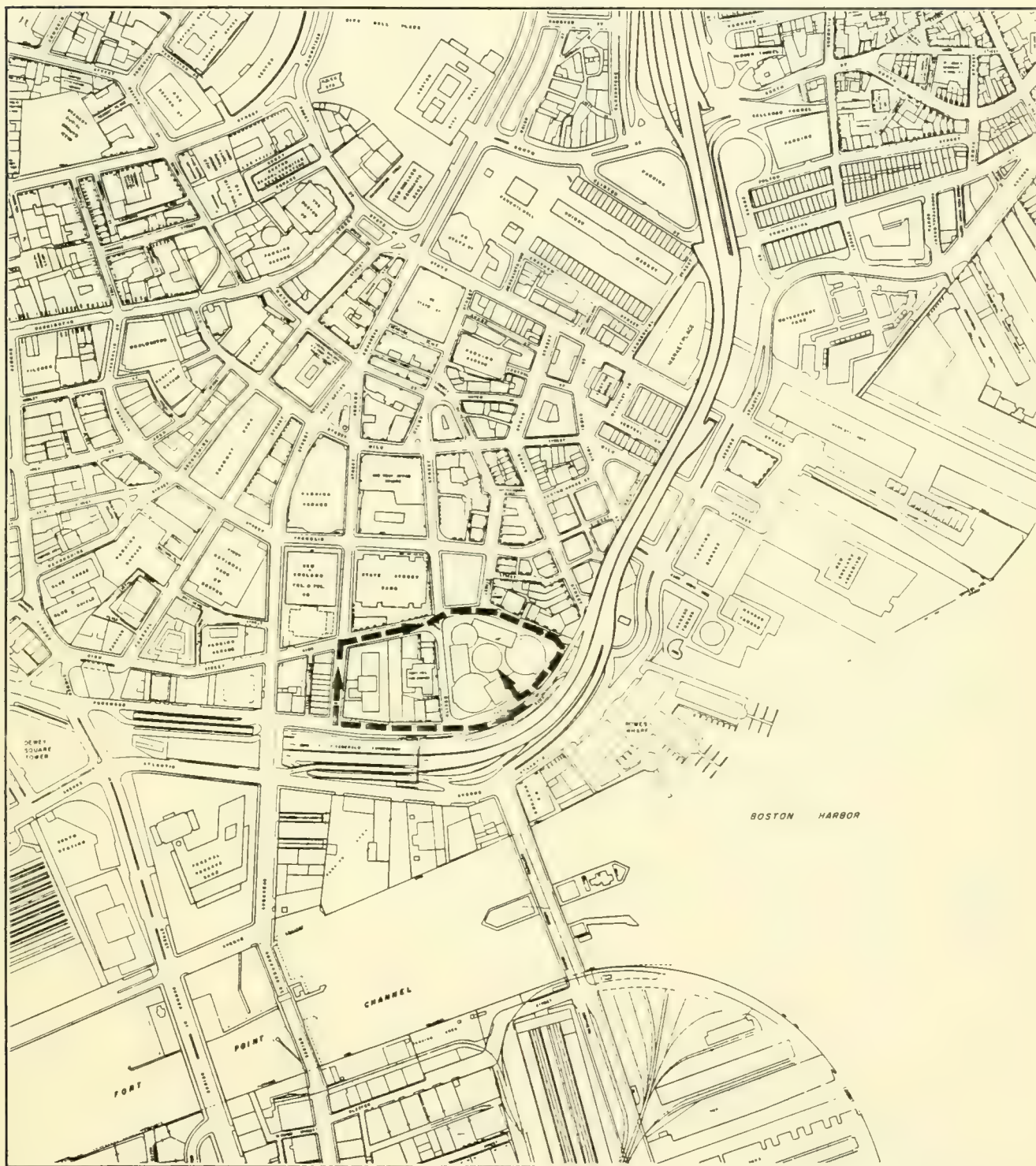
Motorists traveling from the north and destined for the Post Office Square area who currently use the High Street southbound off-ramp will continue doing so. Those motorists from the north and wishing to enter the site garage have three choices:

- use the High Street off-ramp and circle back to the International Place parking garage via Pearl Street, Milk Street, Broad Street and the Surface Artery,
- use the Dewey Square off-ramp and circle back to the garage via Atlantic Avenue, and
- use the Dock Square off-ramp and travel along the Surface Artery to the garage.

Of the three different travel patterns available to the motorists, the Dock Square exit to the Surface Artery is likely the most reasonable in terms of trip length and travel time. Figures 15 and 16 presents site access patterns from the north with and without the ramp relocated.

The impact of these additional vehicles traveling through Dock Square and subsequent intersections will be relatively small during the peak hour. Keep in mind that only AM peak hour traffic will be affected as anticipated inbound trips during the PM peak hour are negligible. During the AM peak hour, it is estimated that approximately 120 vehicles destined to the site could potentially use the Dock Square exit. With three travel lanes on the Surface Artery, these additional trips, will not significantly alter traffic operations along the Surface Artery. In addition, the 120 vehicles

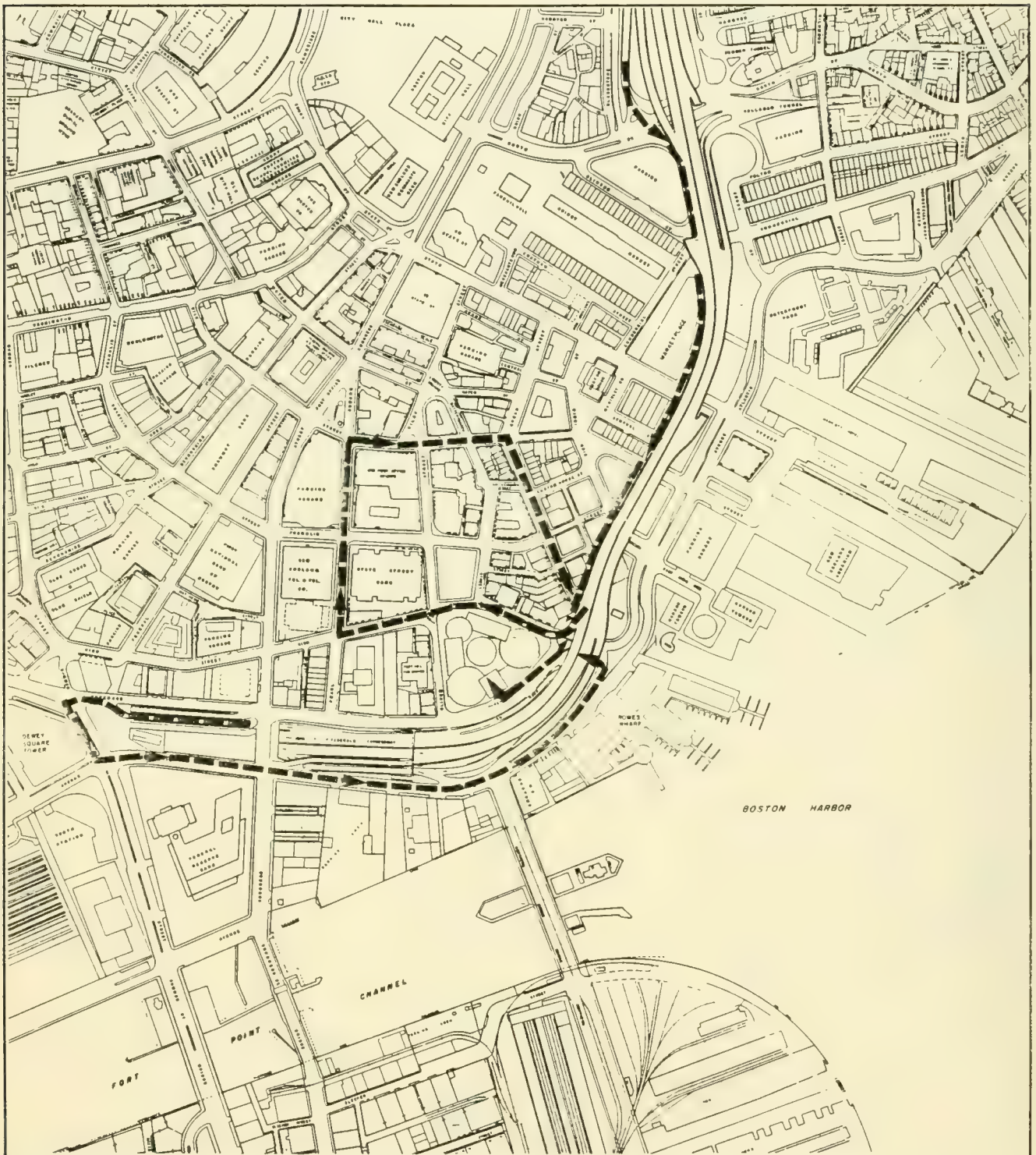
Figure 15 - Vehicle Site Access from North with Ramp Relocation



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Figure 16 - Vehicle Site Access From North Without Ramp Relocation



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represents a maximum estimate as there will be some motorists who choose to use the other two site access routes depending on their own driver behavior habits.

E. RAMP CONSTRUCTION IMPACT ON TRAFFIC FLOW

While the High Street southbound off-ramp is being relocated, there will be some temporary impacts on traffic circulation patterns while both the existing and new ramps are closed to traffic.

Planning for the relocation of the ramp has shown that the overall construction schedule for relocating the off-ramp will be approximately 12 months. Within this time frame, construction on the new ramp would be underway while the existing High Street southbound ramp is still being utilized. Purchase Street will remain open during construction as well. It will only be a period of approximately three to four weeks during the ramp switchover that both the existing High Street off-ramp and the newly relocated ramp would be closed to traffic. Construction could potentially begin in early 1986 and be completed prior to building occupancy. However, as discussed in the comment/response section, design issues related to reconstructing the Central Artery have surfaced the past few weeks which could affect the time frame for relocating the ramp.

During the period both ramps are closed to traffic, motorists who normally use the High Street ramp will likely divert to the Dock Square off-ramp or the Dewey Square off-ramp. Motorists will

then circulate on the downtown network accessing the parking facilities. This will, in all likelihood, last only during the short period of time the ramps are closed to traffic.

In response to comments on the DEIR, a more detailed analysis of the four week traffic impact during the relocation was completed. As discussed in the comment/response section, it is anticipated that approximately 64 percent of the diverted traffic would use the Dewey Square exit while the remaining 36 percent would use Dock Square. The impact on the intersections are shown in Table 28. As can be seen, the Congress Street intersections improve during this time while the Dock Square and Dewey Square intersections will experience additional vehicles into the intersection resulting in somewhat higher v/c ratios. It is anticipated that the Surface Artery intersections north of Dock Square will be minimally impacted by the diverted traffic.

TABLE 28
SUMMARY OF LOS ANALYSIS WITH TRAFFIC DIVERSION
DURING HIGH STREET SOUTHBOUND RAMP CLOSURE
AM PEAK HOUR

	Pre-Ramp Reconstruction		During Ramp Closure	
	V/C ₁ /	LOS ₂ /	V/C	LOS
Purchase Street at Summer Street	0.65	B	0.94	E
Purchase Street at Congress Street	0.94	E	0.81	D
Atlantic Street at Summer Street	0.89	D	1.14	E
Atlantic Street at Congress Street	1.06	E	0.98	E
Blackstone Street at North Street	1.16	E	1.27	E
Surface Artery at State Street	0.68	B	0.69	B

As can also be seen from the results of the analysis, the above intersections most severely impacted are Atlantic Avenue at Summer Street and Blackstone Street at North Street. These two locations have little or no residual capacity to accommodate the diverted traffic.

The intersections of Purchase Street/Congress Street and Atlantic Avenue/Congress Street will experience an improved level of service during this 4 week construction period. Although the Purchase Street/Summer Street intersection will experience the largest increase in approach volume, it is projected to have an ample amount of residual capacity to accommodate the diverted traffic and continue operating at an acceptable level of service. It is not anticipated that traffic conditions along the Surface Artery southbound will be largely affected during the four weeks of ramp closure.

In summary, the closing of the High Street southbound off-ramp will result in a relatively large number of trips diverted to both the Dewey Square southbound exit ramp as well as the Dock Square southbound exit ramp during the AM peak hour in particular. The majority of diverted trips (64 percent) are expected to divert to the Dewey Square ramp as many (estimated 50 percent) commuters presently using the High Street exit ramp appear destined for the Fort Point Channel parking facilities. Although the Purchase Street/Summer Street intersection has the residual capacity to accommodate the diverted traffic, this intersection and the

Atlantic Avenue/Summer Street intersection operating conditions are anticipated to decrease to LOS "E" during the four week construction period. The Dock Square exit ramp is expected to pick up the remaining (36 percent) diverted trips. Additional traffic in Dock Square will result in an increase in the v/c ratio from 1.16 to 1.27, however, the intersection will continue to operate at LOS "E" with motorists experiencing somewhat longer vehicle queues and average delays. During this period extensive police officer control will likely be required at these locations to ease motorists confusion and maximize capacity of specific intersection turning movements.

At the same time, the Purchase Street/Congress Street and Congress Street/Atlantic Avenue intersections will experience lower v/c ratios during the 4 week ramp shut down period. The Purchase Street/Congress Street intersection LOS will actually improve from LOS "E" to LOS "D" during this time. No change in LOS is expected at the Atlantic Avenue/Congress Street intersection.

F. SYSTEM ANALYSIS/DEFICIENCY DELINEATION

1. Street Network Analysis

In the primary study area, the operating conditions of the existing street system is restricted by intersection capacity. Accordingly, an analysis was conducted at several key intersections to determine the level of service provided.

Level of Service (LOS) is a term used to denote the operating conditions on a roadway and is qualitatively measured as the effect of speed, delay, freedom to maneuver and safety. At Level of Service "A", an intersection operates at free-flow conditions. Typically, the intersection approach appears quite open and turning movements are made easily. Seldom, if ever, does a driver have to wait through more than one red signal indication.

Capacity of the intersection occurs at Level of Service "E" and is characterized by consistent backups or queues of vehicles waiting to pass through the intersection. Capacity represents the maximum number of vehicles that can be processed during a given time frame. At capacity conditions, vehicles will always be waiting on approach roadways to use signal green time. In this situation, some motorists may experience significant delays and be forced to wait. There are many intersections in the Boston metropolitan area which currently operate at capacity levels during peak demand periods.

The intersection analysis is based on a sum of critical volumes from each intersection approach and the ratio of this volume to capacity. The capacity is equal to the maximum sum of critical volumes associated with Level of Service "E". Site specific level of service criteria are shown in Table 29. These values were factored during the analysis to reflect the "lost" capacity resulting from pedestrian crossings (i.e. exclusive phases, interference) for each intersection as appropriate.

TABLE 29
LEVEL OF SERVICE CRITERIA^{1/}

Level of Service	Maximum Sum of Critical Volumes			Volume/Capacity Ratio
	Two Phase	Three Phase	Four Phase	
A	900	855	825	0.00-0.60
B	1,050	1,000	965	0.61-0.70
C	1,200	1,140	1,100	0.71-0.80
D	1,350	1,275	1,225	0.81-0.90
E	1,500	1,425	1,375	0.91-1.00

^{1/} Transportation Research Circular Number 212.
"Interim Materials on Highway Capacity,"
Transportation Research Board, Washington,
D.C., January 1980.

Analysis of the roadway impacts are illustrated by Table 30, containing the results of the intersection level of service analysis. The level of service analysis is also summarized in Figure 17.

The analysis of existing AM and PM peak hour conditions indicates that two intersections currently operate at LOS "E" during the PM peak hour only. These include the intersection of Purchase Street at Congress Street and Congress Street at Dorchester Avenue. Several more intersections, along the major arteries, experience levels of service "D", again primarily during the PM peak hour.

Also, under existing conditions, intersections along Franklin Street and High Street operate at high levels of service (i.e. LOS "A") during both the AM and PM peak hours.

TABLE 30
FEIR LEVEL OF SERVICE SUMMARY

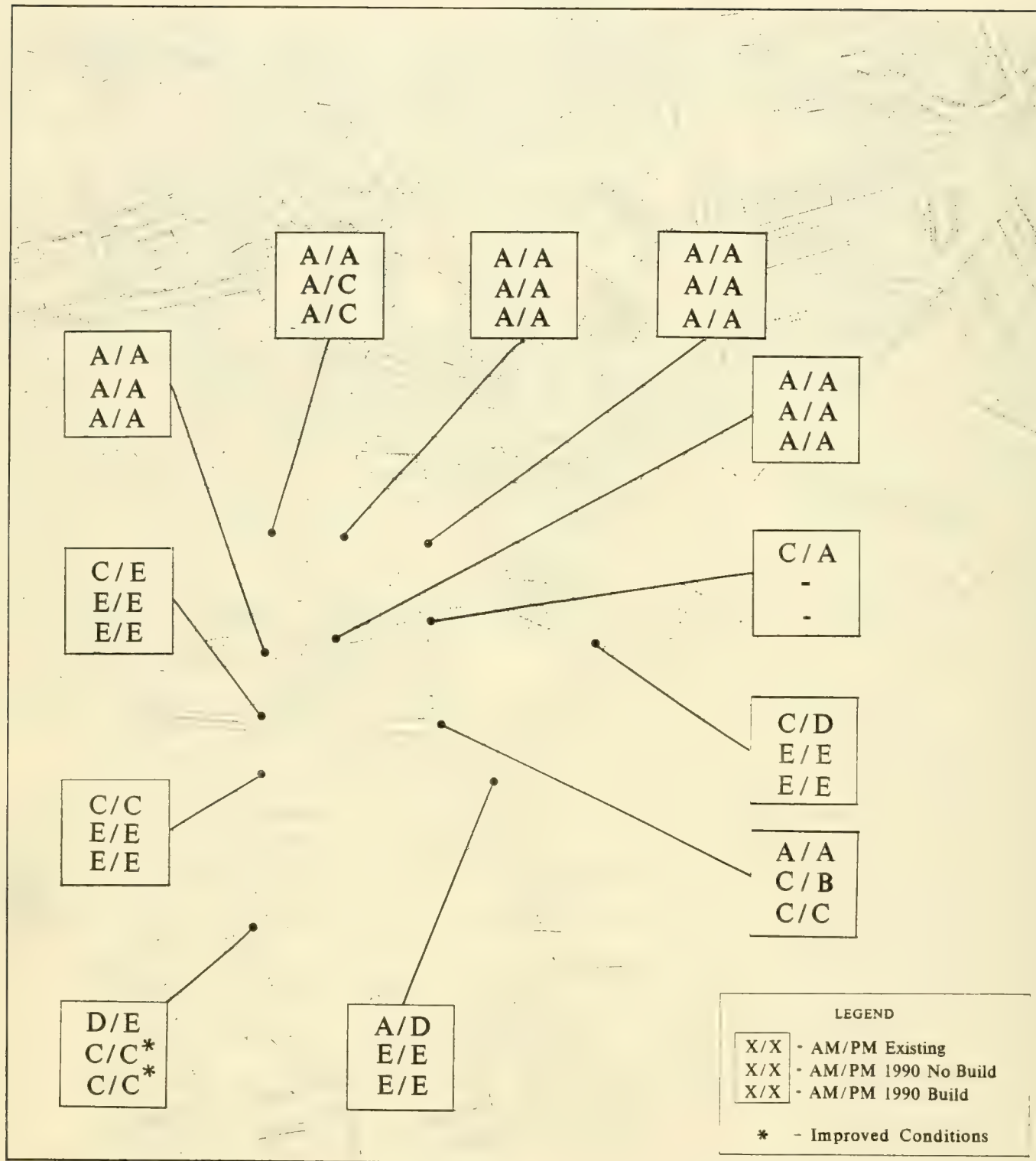
Intersection	Existing				1990 No-Build				1990 Build			
	AM		PM		AM		PM		AM		PM	
	V/C	LOS	V/C	LOS	V/C	LOS	V/C	LOS	V/C	LOS	V/C	LOS
Congress Street at Franklin Street ^{1/}	0.42	A	0.57	A	0.56	A	0.78	C	0.56	A	0.79	C
Congress Street at High Street ^{1/}	0.48	A	0.49	A	0.33	A	0.54	A	0.33	A	0.54	A
Congress Street at Purchase Street ^{1/}	0.75	C	0.94	E	0.94	E	1.17	E	0.94	D	1.23	E
Congress Street at Atlantic Avenue ^{1/}	0.74	C	0.78	C	1.06	E	1.08	E	1.07	E	1.13	E
Congress Street ^{3/} at Dorchester Avenue	-	D	-	E	0.72	C	0.71	C	0.72	C	0.71	C
Atlantic Avenue ^{1/} at Northern Avenue	0.50	A	0.84	D	1.11	E	1.18	E	1.14	E	1.20	E
High Street at Atlantic Avenue/ Surface Artery ^{1/}	0.73	C	0.88	D	1.01	E	1.22	E	1.10	E	1.22	E
Franklin Street at Pearl Street ^{1/}	0.46	A	0.29	A	0.44	A	0.36	A	0.46	A	0.36	A
Franklin Street at Oliver Street ^{1/}	-	A	-	A	-	A	-	A	-	A	-	A
High Street at Pearl Street ^{1/}	0.46	A	0.25	A	0.48	A	0.27	A	0.52	A	0.27	A
High Street at Oliver Street ^{2/}	-	C	-	A	-	-	-	-	-	-	-	-
Purchase Street Oliver Street ^{2/}	-	D	-	A	-	C	-	B	-	C	-	C
Atlantic Avenue/ Summer Street ^{1/}	0.84	D	0.81	D	0.89	D	0.85	D	0.89	D	0.87	D
Atlantic Avenue/ Milk Street ^{1/}	0.39	A	0.80	C	0.47	A	0.96	E	0.50	A	0.96	E
Atlantic Avenue/ State Street ^{1/}	0.53	A	0.87	D	0.64	B	1.05	E	0.64	B	1.07	E
Surface Artery/ Clinton Street/ Commercial Street ^{1/}	0.87	D	0.67	B	1.08	E	0.78	C	1.09	E	0.83	D
Surface Artery/ State Street ^{1/}	0.53	A	0.55	A	0.68	B	0.70	C	0.68	B	0.72	C
Surface Artery/ Milk Street ^{1/}	0.58	A	0.69	B	0.69	B	0.83	D	0.70	B	0.85	D
Black Street/ North Street ^{1/}	0.73	C	0.86	D	1.16	E	1.14	E	1.19	E	1.14	E
Purchase Street/ Summer Street ^{1/}	0.61	B	0.38	A	0.65	B	0.66	B	0.69	B	0.67	B

^{1/} Intersection analyzed using critical movement analysis technique.

^{2/} Intersection analyzed using gap analysis.

^{3/} This intersection analyzed as unsignalized under existing conditions and as improved signalization intersection under the 1990 conditions.

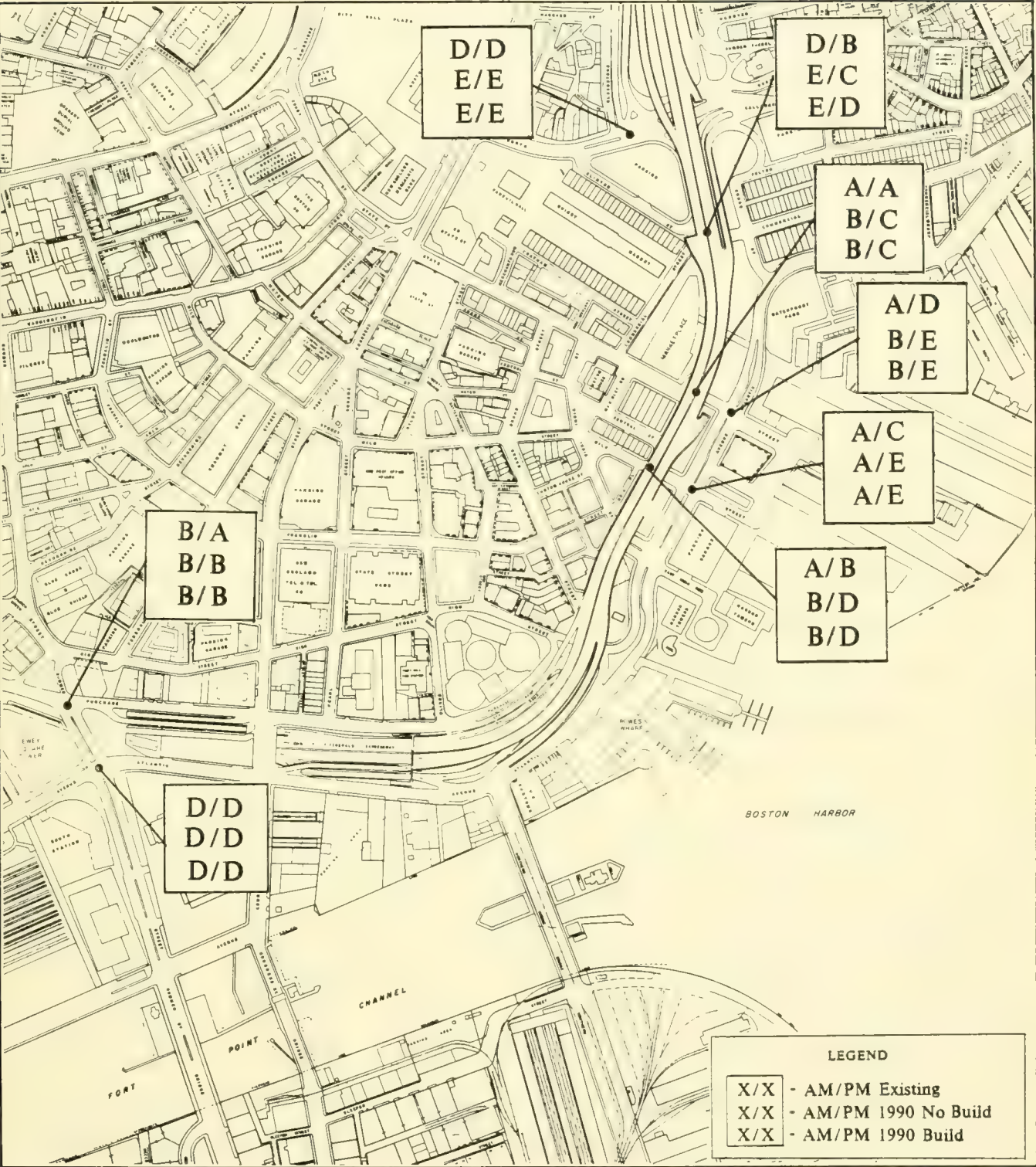
Figure 17a - Level of Service Analysis Summary



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Figure 17b - Level of Service Analysis Summary



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As illustrated by the data in the table, there is not a significant amount of difference between the 1990 No-Build and Build operating conditions. Under the 1990 No-Build and Build conditions, seven of the twenty intersections are projected to operate at low levels of service (LOS "E") during one or both peak periods. These include Congress Street at Purchase Street (PM), Congress Street at Atlantic Avenue (AM and PM), Atlantic Avenue at Northern Avenue (AM and PM), High Street at Atlantic Avenue/Surface Artery (AM and PM), Blackstone Street at North Street (Dock Square) (AM and PM), Surface Artery at Clinton Street (AM), Atlantic Avenue at State Street (PM), and Atlantic Avenue at Milk Street (PM).

Under the Build scenario, these same intersections will continue to operate at the same levels of service as the No-Build alternative with small changes in the volume to capacity ratio and vehicular delay. The result will be longer average vehicle queues and delays at these intersections.

All other intersections analyzed will operate at acceptable levels of service with minimal change from the No-Build situation. This is particularly true for the High Street, Franklin Street and Pearl Street corridors, which continue to operate at high levels of service.

There are only three intersections which are anticipated to experience a reduction in the level of service when compared to the 1990 No-Build. These include Atlantic Avenue at State Street, which goes from LOS "A" to LOS "B" during the AM peak hour, Purchase

Street at Oliver Street from LOS "B" to LOS "C" during the PM peak hour, and the Surface Artery at Clinton Street, which experiences a change from LOS "C" to LOS "D" during the PM peak hour. All of these resulting level of service reductions represent marginal changes (v/c ratio increased by 0.02-0.03) and also represent acceptable peak hour operating levels in an urban environment. In no instance does an intersection operating level fall to LOS "E" as a result of the International Place project.

The intersection analysis has shown that International Place will not have a large impact on the peak hour operating conditions within the study area street system due to several factors. There will be intersections which will operate at a LOS "E" under the No-Build alternative and continue to do so under the Build. The project will increase the number of vehicles being processed through the intersection which will increase queue lengths and delays to a marginal degree (as indicted by the V/C ratios) at the congested locations. The project does not create any new capacity deficient locations due to a relatively small number of peak hour vehicle trips being added to the network at any one location. Factors which help minimize the vehicular impact include parking availability and spatial location, a significant transit utilization factor among its employees and visitors, (which is currently experienced in the financial district), and the projects location relative to the regional highway network (i.e. Central Artery) thereby minimizing a substantial amount of local street traffic circulation volumes.

The intersections which are projected to operate at low levels of service in 1990 under the No-Build alternative will continue to do so under the Build scenario. Any significant changes in traffic flow patterns or operating conditions identified in this analysis are largely due to changes in the roadway system (i.e. reversal of High Street) and not the project itself.

It should also be noted that this analysis of intersection operating conditions depicted in Table 30 represents a worst case situation during the peak travel hour of the day. The analysis is based upon an assumption that vehicular demand generated by the development is not constrained by study area parking supply. In reality, a shortfall in convenient, affordable parking supply may force or encourage auto drivers destined to the site to seek other modes of arrival or share a ride with a co-worker. This would result in fewer vehicles generated by the project than has been projected. The consequences of additional transit passengers, walk trips and trips not made because of the downtown parking situation are discussed in more detail in a later section of this report.

2. Central Artery Ramps

This study includes a discussion of the project's impact on key Central Artery ramps in relation to vehicle queues. The discussion is based on the information presented in the Third Harbor Tunnel/ Central Artery EIS which included a queue analysis of the Central Artery and the other major regional highways in the study area. As

presented in the following paragraphs, traffic volume changes on the Central Artery on- and off-ramps which serve the site and vehicle queues on the ramps were studied.

Traffic Volume Changes

Table 31 summarizes the changes in traffic volumes anticipated to occur on the affected central ramps during the peak hours as a result of the project. As defined in the MEPA Scope, six ramps in addition to Dock Square were to be assessed. The added peak hour volumes to individual ramps are relatively small as shown in Table 31. This is based on the trip distribution and trip assignment results which were based on several assumptions with regard to available parking. The assignment of trips between the parking facilities and the Central Artery ramps was dependent on the facility location and the shortest path to the Artery. As stated earlier in the report, the parking facilities which are assumed to serve the project include a major supply addition at South Station, Post Office Square, the Aquarium Garage, Rowes Wharf and the site garage. The trip assignment did not assume parking would be available across the Fort Point Channel. The motorists destined for the South Station parking facility are also assumed to have a direct connection to the facility from the highway. The direct connection avoids having motorists exiting the Artery on one of the ramps shown in Table 31 and adding to local street traffic.

TABLE 31
SUMMARY OF CENTRAL ARTERY ON- AND OFF-RAMP
TRAFFIC VOLUME SUMMARY

	1990 No-Build		1990 Build		Change	
	AM	PM	AM	PM	AM	PM
Congress St. NB On-Ramp	1,292	1,221	1,292	1,291	0	70
Northern Ave. NB On-Ramp	745	1,221	745	1,254	0	33
High St. NB Off-Ramp	1,574	1,507	1,661	1,512	87	5
Relocated High St. SB Off-Ramp	1,426	555	1,498	550	72	5
Purchase St. SB On-Ramp	730	1,027	730	1,105	0	78
Congress St. SB On-Ramp	423	1,396	423	1,543	0	147
Dock Square SB Off-Ramp	1,497	1,374	1,526	1,376	29	2

The largest increase is on the Congress Street southbound on-ramp which is projected to increase by 147 vehicles during the PM peak hour. Other ramps which are anticipated to carry a major portion of the remaining PM trips include the Congress Street northbound on-ramp (70 trips), the Northern Avenue northbound on-ramps (33 trips) and the Purchase Street southbound on-ramp (78 trips).

During the morning, three of the identified off-ramps will experience volume increases including the relocated High Street southbound off-ramp (72 trips); the High Street northbound off-ramp (87 trips) and the Dock Square off-ramp (29 trips).

Vehicle Queues

As stated previously, vehicle queues on the Central Artery, Southeast Expressway, Massachusetts Turnpike, Storrow Drive, and the

existing tunnels were studied as part of the Third Harbor Tunnel/Central Artery EIS. In conducting the queue analysis, relationships between the physical roadway capacity, traffic volumes, queues, and delays were taken into account. That study was primarily concerned with the mainline roadway segment, however, major ramps connecting two major facilities were also studied. The importance of the analysis conducted during the EIS is that mainline traffic behavior will also affect the operations of the "minor" ramps which connect the Artery with the local street system.

The findings of that analysis and more recent observation are briefly summarized below:

- During the existing AM peak hour, major vehicle queues, delays and bottlenecks occur at the High Level Bridge over the Charles River where the I-93 traffic from the north merges with Mystic-Tobin Bridge traffic. A seven to eight minute delay is experienced.
- The Sumner Tunnel is another location for morning delays and vehicle queues affecting traffic from the north. From the south, "intermittent" queues occur along much of the expressway as no well defined bottleneck location exists with the exception of the Massachusetts Turnpike on-ramp merge which experiences approximately one and one-half minute delay.

- The Central Artery from the High Level Bridge to the South Station tunnel does not typically experience any major queues in the morning peak hour as there are several off-ramps which allow motorists destined for Downtown Boston to exit the Artery. Related to this, significant vehicle queues on the off-ramps also do not occur during the morning peak hour due to several factors including the free flow conditions at the junction of the off-ramps with the local street (i.e. High Street southbound off-ramp) and the ramps which are controlled by traffic signals at their junctions have the length and width to easily accommodate the demand.
- One exception during the AM peak hour is the Dock Square southbound off-ramp which on occasion experiences long vehicle delays and queues, particularly if a breakdown occurs in the Callahan Tunnel. Since the one-way tolls were introduced the occurrence of long queues reaching the Central Artery during the morning happens less frequently. The other two factors which influence traffic flow in this area are the weaving that takes place between the Haymarket southbound on-ramp and the Dock Square off-ramp, and the uncontrolled Dock Square intersection.
- During the PM peak hour, a major mainline vehicle queue occurs in the northbound direction. One major cause includes the bottleneck created on the High Level Bridge where five entering lanes merge into three. This queue has at times stretched from the High Level Bridge to the Massachusetts Avenue exit

off the Southeast Expressway. The other major cause which is apparent at times is the queue from the Callahan Tunnel. This queue, which occurs in the outer most travel lane, creates conflicts between mainline and ramp merge volumes. However, with travel speeds very slow on the mainline, the ramp volumes are typically able to enter the mainline flow and cross to the other two moving travel lanes.

- The Central Artery in the southbound direction from the High Level Bridge to the South Station tunnel typically does not experience the vehicle delays and queues that do occur in the northbound direction. Moving and intermittent queues do take place from the Massachusetts Avenue interchange to the Route 3/Route 128 split. However, due to the adequate interchanges with the Massachusetts Turnpike and Massachusetts Avenue, flow on the Central Artery in the southbound direction generally is moving, although low travel speeds. Again, the one exception is the Dock Square exit ramp where the effect of the Callahan Tunnel at times results in vehicle queues stretching from Dock Square to the High Level Bridge.
- By 1990, Central Artery traffic flow conditions are anticipated to generally become worse without major regional highway improvements. Some relief will occur as the North Area project is expected to be implemented. This project will eliminate the bottleneck condition which currently occurs at the High Level Bridge.

Local Ramps

- In general, the Central Artery on-ramps, with some exceptions as stated above, do not experience long vehicle queues during the peak hours. This is due to a combination of factors including the ability of ramp traffic to merge into the Central Artery mainline because of low mainline travel speeds, metering of motorists entering ramps through traffic control, sufficiently wide ramps to accommodate two travel lanes, and the travel behavior of motorists who upon seeing congestion on one ramp will travel along the local street system to the next ramp.
- Due to these factors, several downtown on-ramps do not experience long delays and queues. These include the Purchase Street on-ramp, the Congress Street southbound on-ramp, and Congress Street northbound on-ramp. The on-ramp which does tend to experience more significant queues during the PM peak hour is the Northern Avenue northbound on-ramp. The following discussion centers on this ramp and the related Northern Avenue intersection with Atlantic Avenue and the Atlantic Avenue northbound off-ramp.

Northern Avenue Northbound On-Ramp

The analysis of this ramp is largely related to the flows along Northern Avenue and Atlantic Avenue and the operating conditions of

the intersection of the two roadways. A previous study^{1/} conducted an in-depth analysis of this intersection and its results are summarized below. This information is supplemented with the changes anticipated as a result of International Place.

The Northern Avenue/Atlantic Avenue intersection currently functions as a congestion point (or bottleneck) due to the two conflicting heavy uncontrolled traffic streams which come together at this intersection. The problem is further complicated by the fact that the Central Artery has both on- and off-ramps at this location. Also, a large number of drivers get off the Artery in the Dewey Square Tunnel at the Atlantic Avenue/Northern Avenue exit and then immediately rejoin the Artery on the Northern Avenue on-ramp. This occurs primarily during the afternoon travel periods. This shortcut contributes significantly to the traffic using the north-bound on-ramp during the peak hours, accounting for approximately 20 percent of the ramp's total volume.

As stated earlier in this action, the additional ramp volumes were assigned with respect to anticipated vehicle routings between the Artery and the parking facilities. With the spatial location of the parking facilities, the effect of the volumes on each individual ramp is reduced as the volume impact is spread over the entire downtown ramp system. Based on the anticipated routing paths, the project will add approximately 33 vehicles on the Northern Avenue

^{1/} Skidmore, Owings & Merrill, Final Environmental Impact Report, Commonwealth Pier, Five Redevelopment, prepared for Massport, September, 1982.

northbound on-ramp during the PM peak hour, representing a less than 3 percent increase. This also assumes that the motorists (70 during PM peak hour) who enter the Congress Street northbound off-ramp do not divert to the Northern Avenue on-ramp.

During the afternoon peak hour, the Northern Avenue/Atlantic Avenue intersection currently operates at capacity for a portion of the hour. During this time, a significant queue builds up across the Northern Avenue bridge, occasionally reaching as far back as the entrance to the Piers 1, 2 and 3 parking lot. This queuing is due to the fact that Atlantic Avenue operates under generally free flow conditions while Northern Avenue operates under stop control. At the same time, the queue buildup on the northbound on-ramp to the Central Artery generally fills up approximately one-third of this 750 foot long ramp. Vehicles stack in two lanes and the capacity of this ramp is restricted by the merge with the Central Artery. If a queue exists over the course of an entire hour (as it does on the northbound on-ramp), any additional traffic on the ramp would add to the queue since theoretically it could not be processed due to downstream congestion. However, observation of this location indicates that the ramp volume is able to force a merge into the Artery's outermost travel lane, due to low mainline speeds, and then cross into the two other lanes in which traffic is generally moving.

Theoretically, all of the new additional traffic destined for the on ramp would add to the queue of vehicles waiting to be processed. This is not likely to happen, however, for three

reasons: 1) The Northern Avenue/Atlantic Avenue intersection currently functions as a capacity constraint for traffic on the Northern Avenue approach, 2) in response to traffic congestion, many drivers alter their routes to travel the route of least resistance and 3) drivers shift their arrival and departure times to avoid periods of peak congestion. In addition, two major physical changes which will affect traffic operations are also being made at the Northern Avenue intersection. The relocation of the Northern Avenue bridge and the installation of a traffic signal will do two things: 1) it will lengthen the storage area for vehicles queuing on the northbound on-ramp by approximately 150-200 feet and 2) it will increase delays and introduce queuing to both Atlantic Avenue and the northbound off-ramp.

What will likely happen then, in our opinion, is a combination of an increase and lengthening of the peak hour traffic congestion and a shift in traffic volumes.

It is expected that a shift in traffic volumes on the on-ramp will occur. As stated previously, there is an afternoon peak hour demand by 200-300 vehicles who currently exit the Central Artery at Northern Avenue and then immediately rejoin the Artery via the Northern Avenue on-ramp. With the installation of a signal at the intersection, it is expected that this movement would no longer take place due to the new delays introduced by the signal. These vehicles would instead remain on the Artery and as a result would reduce the effective ramp/merge capacity. Assuming the vehicles

are spread over the three Central Artery northbound lanes, the ramp/merge capacity could be expected to decrease by approximately 100 vph. This shift in volumes would also reduce the ramp demand by approximately 150 as two lanes exist on the ramp.

Other possible shifts in northbound traffic volumes could occur along several alternate routes. One alternative route is to use Atlantic Avenue and Commercial Street as a northbound bypass to City Square in Charlestown where regional connections can be made. A second, although less desirable option would be to use the Surface Artery, Clinton Street and North Street to access the Central Artery Northbound at the Sumner Tunnel on-ramp. Other routes also exist. Another change that may take place is that northbound traffic on Atlantic Avenue may choose to use the Congress Street on-ramp to the Artery, rather than pass through another signal at Northern Avenue. It is difficult to determine exact vehicle routings because of the variability in traffic conditions on the Central Artery and the surface street system from day to day. Traffic conditions are clearly a function of a number of factors including, but not limited to: accidents or breakdowns, illegal parking and pedestrian crossings, the weather, the time of day and season. As a worst case analysis, the only shift assumed was the Northern Avenue off-ramp to on-ramp short cut.

Assuming only the shift of the motorists who now use the Northern Avenue northbound on-ramp as a Central Artery bypass, the 1990 No-Build queue on the ramp was estimated. The estimate was based on the Commonwealth Pier analysis which identified:

- The existing queue on the northbound on-ramp is approximately one third its length or 250 feet.
- The No-Build alternative could potentially result in a queue length of 850 feet. The improvements to the Northern Avenue Bridge and the intersection itself, result in a ramp storage length of approximately 950 feet. This indicates that the ramp volume should not back up into the intersection.

The additional vehicles onto the ramp projected as a result of this project will theoretically add 16 vehicles or 300 feet to the queue assuming the additional vehicles utilize two lanes on the ramp. These additional vehicles, although not a large number by themselves could potentially result in the queue backing up into the intersection.

However, as stated earlier, because of the traffic signal installation at this intersection, alternatives northbound ramps and routes for motorists to use, and the potential shifting of departure times, it is unlikely that the ramp queue will back up into the intersection affecting its operations. In response to comments on this potential intersection blockage, it may be appropriate to implement traffic management actions in the short-term such as police officer control, and increased surveillance of Artery flow to ensure blockage at the intersection does not occur.

3. Transit System Analysis

The proposed project as previously described will generate approximately 16,578 transit trips on a typical day -- 8,259 entering the site and 8,259 leaving the site. Peak hour transit trips from the project account for a considerable portion of the daily transit trips (3,130± AM and 3,250± PM). Based on published results of the 1982 Boston cordon count conducted by the City^{1/}, it was possible to determine a breakdown of transit trips by subway, commuter rail and express bus routes. The data indicated that in 1982, of the cordon crossings by transit 70 percent were made by subway, 23 percent by express bus routes and 7 percent by commuter or intercity rail. This analysis concentrated on the subway ridership since its capacity will be relatively fixed. The commuter rail and express bus systems can more easily increase capacity to meet increased demands.

The site is in relatively close proximity to the Red, Orange, Blue, and Green Lines, and, as a result, these lines were included in the analysis. Table 32 summarizes the comparison of ridership levels and passenger capacities during the peak hour period.

The capacities shown in the Table represent future capacities under improved conditions for the Red and Orange Lines (i.e. 6 car trains). The future base ridership levels (peak direction flows)

^{1/} Institute of Transportation Engineers, ITE Journal, "The 1982 Boston Cordon Count", January, 1984.

TABLE 32
RAPID TRANSIT CAPACITY ANALYSIS

	Existing Capacity ^{1/}	Existing Ridership ^{2/}	Existing V/C ^{3/}	Future Capacity	Future Base Ridership	Future Base V/C	Future Build Ridership	Future Build V/C
<u>Red Line</u>								
Harvard-Ashmont	10,740	4,630	0.43	11,710	5,451	0.47	5,654	0.48
Harvard-Braintree	10,740	7,490	0.70	11,710	8,882	0.76	9,224	0.79
<u>Ashmont</u>								
and Braintree - Harvard	21,480	6,440	0.30	23,420	9,638	0.42	9,865	0.42
<u>Green Line</u>								
North Station - Cleveland Circle	3,420	2,420	0.71	3,420	3,065	0.90	3,168	0.93
Government Ctr. - Boston College	3,420	2,120	0.62	3,420	2,692	0.79	2,783	0.81
Lechmere - Riverside	4,070	2,500	0.61	4,070	3,167	0.78	3,274	0.81
Park Street - Arbway	4,280	2,090	0.49	4,280	2,629	0.61	2,712	0.63
Riverside- Lechmere	4,070	1,100	0.27	4,070	1,609	0.40	1,609	0.40
<u>Orange Line</u>								
Oak Grove - Forest Hills	12,600	7,080	0.56	18,910	10,113	0.53	10,613	0.56
Forest Hills - Oak Grove	12,600	10,270	0.82	18,910	13,719	0.73	14,037	0.74
<u>Blue Line</u>								
Bowdoin - Wonderland	8,900	6,120	0.84	8,900	7,400	0.83	7,718	0.87

^{1/} Capacity estimation reflects 1.75 square feet per standee.

^{2/} Ridership = peak hour passengers.

^{3/} V/C = volume to capacity ratio.

were determined by applying an annual growth rate based on historical data to the existing ridership levels as well as specifically accounting for the transit ridership from the Marketplace Center, the Dewey Square Office Building, the St. James Garage Redevelopment project and additional expected trips from the Copley Place Development. The Build ridership includes adding the project demands to the base future ridership.

The analysis shows that transit passengers generated by the project can be accommodated on all lines. As indicated by the volume to capacity ratios, it can be seen that the proposed development does not introduce capacity constraints (bottlenecks). The improved transit system (6 car train vs. 4 car trains and accommodating platform extension) adding capacity to the Red and Orange Lines, will enable the system to accommodate additional riders in the event that there is a further citywide shift in mode choice in the event parking supply improvements are not implemented to meet future demands.

Lines which are improved by 1990 may experience lower v/c ratios in 1990 than under existing conditions. For example, the Orange Line (Forest Hills - Oak Grove direction) v/c under existing conditions is 0.82 while under the build alternative is 0.74. This is due to the change in line capacity as six car trains are anticipated to be in operation by 1990.

The analysis indicates by the volume to capacity ratios of 0.7 and above that demand for transit service will result in standee

conditions and in some instances, crowded conditions on most trains during the peak hour. As seen in the table, this condition can be expected on the Harvard-Braintree route on the Red Line, most Green Line routes, the Forest Hills - Oak Grove route on the Orange Line and Bowdoin - Wonderland route on the Blue Line. The North Station - Cleveland Circle route indicates that better than 90 percent of the cars operating on that route during the peak hour will not have excess capacity. Relief to the Arborway line will likely occur when relocation of the Orange line occurs.

These data indicate that there is residual transit ridership capacity available on the various MBTA lines during the peak hour. As will be discussed in the Parking Analysis Section, this residual will be important to downtown growth and the region's transportation system if major parking improvements are not advanced. As under existing conditions, there will likely be some degree of waiting for subway trains with seating or standing space. However, overall peak hour ridership can be accommodated over the course of the hour. International Place will not result in any noticeable change in passenger delay over the No Build condition.

4. Parking Impact Analysis

The continued rapid development of the downtown has placed considerable pressure on all of the city's parking supply. The Boston Parking Study concluded that before the end of the decade, assuming no major changes in parking supply or travel characteristics at the current development pace, there would be a citywide

shortage of 2,400 spaces at 10:00 AM on a typical weekday. By 12:00 noon, the citywide shortage would be 8,000 spaces. Assuming no improvements to supply between 1985 to 1990, that study projected large increases to the shortage. Based on these findings, the study recommended a three-pronged approach to solving the parking problem:

- o Increasing the supply of spaces,
- o Reducing long-term parking demand, and
- o Making more space available for short-term parkers.

It is our understanding the City is still reviewing the recommendations of the study. For the purposes of this analysis, we have assumed they will be well along to implementation by 1990.

The following sections of the report discuss the future growth in parking demand in the study area, changes in parking supply and specific impacts of the project.

a) Background Parking Demand

As indicated earlier in this report several development projects are either recently completed, well under construction or through the approval process and will be fully operational prior to 1990. These projects include:

- o Exchange Place,
- o Devonshire Towers,
- o 260/265 Franklin Street,
- o 155 Federal Street,
- o Market Place Center, and
- o Rowes Wharf.

The parking demand within the study area is expected to increase by 3,725 spaces as a result of these projects. This does not include the demand expected to be created by the Piers 1,2,3 and 4 development. Since this development is expected to meet its own parking demand on-site it will not add to the projected parking shortfall. This development will, however, eliminate a parking resource which is currently used by commuters to the Financial District. Changes in overall parking supply are discussed in the following section.

b) Development Related Supply Changes

As discussed earlier several construction projects have eliminated some of the available parking supply, as these developments are completed several spaces lost during construction will be replaced. For example, Exchange Place is providing 120 spaces in place of the 93 surface spaces that occupied the site. Similarly the Rowes Wharf project will provide 575 spaces in place of the 225 spaces formerly occupying the site. In total (with the exception of the Piers 1, 2, 3, and 4 project) new development will replace approximately 1,200 parking spaces in the area.

On the reduction side of the ledger, the Pier 1, 2, 3 and 4 project will eliminate 2,000 spaces currently used by downtown parkers.

c) Base Parking Supply/Demand Condition

Table 33 presents the 1990 baseline parking conditions without the proposed project related demand and without any new public parking construction as delineated in the Boston Parking Study. As the can be seen, a sizeable parking space deficit on the order of 3,200 parking spaces results. It should be pointed out again that this assumes the elimination of 2,000 parking spaces on Northern Avenue accross the Fort Point Channel by 1990 which is an unlikely occurance in that time frame.

TABLE 33
STUDY AREA PARKING SUPPLY/DEMAND RELATIONSHIP WITHOUT PROJECT

	Existing Condition	1990 Base Condition ^{1/}
Area Parking Supply	11,600	10,800
Area Parking Demand	10,300	14,025
Surplus (Deficits)	1,300	(3,225)

^{1/} Assumes 2,000 spaces on Piers 1, 2, 3 are eliminated by 1990.

d) Project Parking Demand

The demand for parking spaces created by International Place can be estimated by employing the same assumptions used in the trip generation forecasts for the project. Parking requirements are divided into long-term employee parking and short-term shopper/business parking.

The peak parking demand was estimated by determining the number of employee and non-employee vehicle trips over the course of the

day and applying an assumed arrival time factor for employees and the observed average duration for short term parkers in this area of Boston.

Based on the trip forecasting procedure described earlier, it is anticipated that a total of 2,328 vehicles will be attracted by the project over the entire day. Of this total, 1,306 vehicles are driven by employees, while 1,022 are vehicles driven by visitors, taxis and delivery type vehicles.

Long-term peak parking demand was estimated by assuming that 90 percent of the employees who drive to work arrive during the morning and stay all day. There will be some employees who arrive later in the day in relation to retail and restaurant establishments as well as some employees who do not remain at the office. Applying 90 percent factor to the 1,306 employee driven autos, the long term peak parking demand is estimated to be 1,175 vehicles.

In determining the short term peak parking demand, the different type of short term parkers who make up the 1,022 vehicles had to be determined. As discussed under travel demands, the number of taxis (200), and delivery trucks (200) were estimated. This leaves approximately 622 private vehicles who represent short-term parking demand.

For estimating short-term peak demand, several assumptions were made including:

- Taxis were not counted as short-term demand as a separate passenger loading area will be designated adjacent to the site to serve the taxis.
- Off-street loading docks are part of the project with access located on Purchase Street. However, many deliveries such as courier service will likely utilize on-street curb space. For this reason it will be appropriate to designate some curbspace for delivery vehicles. Delivery vehicles, however, were not counted as short-term parking demand.
- On-street space turnover in the Financial District was observed to average 2.67 vehicles per space, per day based on eight hour days.

Table 34 summarizes the peak parking demand analysis following the application of the above factors.

TABLE 34
PEAK PARKING DEMAND ANALYSIS SUMMARY

	Spaces
<u>SHORT-TERM</u>	
<u>Total Daily Demand</u>	622
<u>Peak Demand Estimate:</u>	
Visitors = 622 vehicles ÷ 2.67 vehicles/space - hour	
<u>Total Short-Term Peak Demand</u>	233
<u>Long Term Peak Demand</u>	1,175
<u>Total Peak Parking Demand</u>	1,408

Based on the travel forecasts, it is estimated that the proposed project at full development will generate a new peak demand for 1,408 parking spaces, broken down by type as follows:

Long Term	- 1,175 spaces
Short Term	- <u>233</u> spaces
Total	1,408 spaces

An existing demand of approximately 700 parkers must be accommodated in addition to the project's own demands. These parkers currently use the Fort Hill Garage and the adjacent surface lots.

e) Parking Supply/Demand Condition With Project

The site currently includes the Fort Hill Garage which contains 660 parking spaces as well as a surface lot which includes approximately 167 spaces. After construction of the project, there will be approximately 827 off-street spaces on site which represents a minimal change. Table 35 summarizes the anticipated parking supply/demand relationship in the study area after the project is completed. As can be seen there is no change in parking supply assumed therefore, the areawide space deficit will increase to approximately 4,600 parking spaces. Again this assumes the loss of 2,000 parking spaces on Fort Point.

TABLE 35
STUDY AREA PARKING SUPPLY/DEMAND RELATIONSHIP
WITH INTERNATIONAL PLACE

	Existing Condition	1990 Base Condition ^{1/}	1990 With Project ^{1/}
Area Parking Supply	11,600	10,800	10,800
Area Parking Demand	10,300	14,025	15,425
Surplus/Deficit	1,300	(3,225)	(4,625)

^{1/} Assumes 2,000 spaces on Piers 1, 2, 3 are eliminated by 1990.

f) Public Parking System Improvements

As described earlier, the Boston Parking Study has defined a three part strategy for alleviating the potential parking shortage in the Downtown. One element of the strategy is the addition of parking supply. A specific recommendation affecting the International Place EIR study area is the construction of 3,000 new public spaces at South Station as part of the Transportation Center project. It is envisioned that this facility would be connected to the regional highway system by direct ramps there by minimizing impact on the local street system. While a portion of these spaces would be used to service the need created by South Station area development (i.e. Dewey Square Tower), a substantial reserve on the order of 2,000-2,500 could be expected to relieve deficits created by development in the Financial District and Fort Point Channel.

A second recommendation of the parking study was the addition of 1,500 parking spaces at North Station. While not directly relieving the parking shortage in the study area it may result in

shifting parking demand. Since by 1990 the North Station area is expected to experience only a minor deficit, 1,500 new spaces would create a considerable reserve to serve adjacent areas much in the manner Fort Point Channel parking parking currently serves the Financial District.

Finally, although not a recommendation of the Parking Study, a group of concerned area businessmen known as Friends of Post Office Square have proposed reconstruction and expansion of the City's Post Office Square Garage adding 500 new parking spaces. These spaces would directly relieve a portion of the parking shortage in the Financial District.

Together these three actions would reduce the parking shortage in the study area by as much as 3,000-3,500 spaces. There would, however, still be a parking shortage of 1,100 to 1,600 spaces. It is most likely that this shortage would be made up by changes in travel characteristics of commuters. Table 36 summarizes the 1990 parking situation assuming new public supply is available.

TABLE 36
1990 PARKING SUPPLY/DEMAND RELATIONSHIP
ASSUMING NEW PUBLIC SUPPLY

	1990 No-Build	1990 Build
Area Parking Supply ^{1/}	13,800	13,800
Area Parking Demand	14,025	15,425
Surplus (Deficit)	(225)	(1,625)

^{1/} Assumes 2,250 new spaces available @ South Station, 500 new spaces available @ Post Office Square and 250 new spaces made available by parking transfers to North Station.

Implementation of these new parking supplies will require modifications to the current parking freeze as discussed earlier in this report.

g) Implications of a Parking Shortage

If there is not a sufficient parking supply for all who wish to drive into Boston to work or conduct business, there will likely be a shift in travel characteristics. A shift from single occupant vehicles toward increased use of carpools, vanpools, and public transportation would probably occur. It is also possible that a slow down in the rate of new development would occur. However, it is our opinion that the parking shortage would have to be severe and alternatives very unattractive before development would slow down noticeably.

The least likely outcome of a parking shortage would be a long term increase in illegal on-street parking given that streets are currently used to capacity and the City pursues an aggressive enforcement posture.

For the purposes of assessing the implications of the projected parking shortage, it has been assumed that the shortage impacts long-term commuter parking only. Under today's condition, the opposite (i.e. short term parking) would be true and the impacts on the transportation system less significant (i.e., off-peak). However, as recommended in the Boston Parking Study and demonstrated through recent Boston Air Pollution Control Commission

decisions, there is a greater emphasis on the needs of short-term parkers in the City. It is expected a higher proportion of new spaces will be used to meet short term parking demands.

It has also been assumed that all unsatisfied parking trips would be made by an alternate mode (i.e. carpool, vanpool, or public transportation).

● Shift To Ridesharing

The Boston Parking Study indicated the existing study area off-street parking accumulation at 10:00 AM to be approximately 9,400 autos. If it is assumed that these are financial district related commuter vehicles with an average occupancy of 1.8 persons^{1/} per auto, it is conservatively estimated they carry 16,900 commuters. New development is expected to generate 6,400 new commuters arriving by auto in approximately 3,500 vehicles. However, as previously noted, 1,600 of these autos carrying approximately 2,900 commuters will not be able to find a parking space. Therefore, if the overall split between auto and non-auto modes of arrival were to remain constant, the citywide average work-trip vehicle occupancy rate (VOR) would have to increase by approximately 14 percent to 2.06 persons per auto. Although average auto occupancies in this range have been observed at individual buildings, it is unreasonable at this time, to realistically see a downtown average vor of 2.06. A more reasonable expectation would be a split between increased

^{1/} Average auto occupancy of office workers observed in financial district.

ridesharing and increased transit use. If one-third of the commuters making up the parking space shortfall shift to carpools, the average VOR would increase by 5 percent to 1.89 persons per auto. Such an increase would reduce the potential parking shortage in the study area by approximately 600 spaces.

● Shift To Public Transit

Assuming an increase in the study area VOR to 1.89 persons per auto for downtown work trips, approximately 1,800 additional person trips would still have to shift from the auto mode to public transportation to completely eliminate the parking shortage. Of these, approximately 55 percent or 990 person trips could be expected to occur during the peak hour. Using the same trip distribution pattern as discussed in the Transit Impact section, the following tables summarize the subway system impacts by line (assuming 70 percent of the transit diversion is to the subway system).

As can be seen in Table 37, the increases in V/C ratios on the transit system resulting from the potential parking shortage in the study area are relatively small and will not affect projected transit operations alone. It must also be noted, however, that this analysis only examines a portion of the entire city. According to the Boston Parking Study, comparable parking shortages will likely exist in other parts of the city by 1990. The cumulative effects of all potential mode shifts resulting from the overtaxed city parking system may have more significant impacts on the transit system.

TABLE 37
RAPID TRANSIT CAPACITY ANALYSIS SUMMARY
WITH MODE SHIFT

		Build Without Mode Shift		Build With Mode Shift	
	Capacity ^{1/}	Ridership ^{2/}	V/C ^{3/}	Ridership	V/C
<u>Red Line</u>					
Harvard-Ashmont	11,710	5,621	0.48	5,684	0.49
Harvard-Braintree	11,710	9,224	0.79	9,327	0.80
Ashmont and Braintree - Harvard	23,420	9,865	0.42	9,927	0.42
<u>Green Line</u>					
North Station - Cleveland Circle	3,424	3,168	0.93	3,197	0.93
Government Ctr. - Boston College	3,424	2,783	0.81	2,812	0.82
Lechmere - Riverside	4,066	3,274	0.81	3,303	0.81
Park Street - Arborway	4,290	2,712	0.63	2,741	0.63
<u>Orange Line</u>					
Oak Grove - Forest Hills	18,910	10,613	0.56	10,765	0.57
Forest Hills - Oak Grove	18,910	14,037	0.74	14,134	0.75
<u>Blue Line</u>					
Bowdoin - Wonderland	8,896	7,718	0.87	7,815	0.88

^{1/} Capacity estimation reflects 1.75 square feet per standee.

^{2/} Ridership = peak hour passengers.

^{3/} V/C = volume to capacity ratio.

5. Pedestrian Analysis

With a large portion of person trips generated by International Place traveling via transit, there will be a significant number of pedestrians walking to and from the site. In addition, as parkers will utilize a variety of parking facilities in the general vicinity of the site, pedestrian movements from the parking locations to and from the site will also occur. Figure 18 shows likely pedestrian paths from the major parking locations as well as the transit stations serving the project.

During the commuter peak hours, it is estimated that 4,440 pedestrians will be either entering or exiting the site. The 4,440 pedestrians include all transit riders, walkers and parkers. As shown in Figure 18, there are three general areas which attract the pedestrians generated by International Place. The three general areas are Aquarium Station/Waterfront area, South Station area and Government Center/Financial District area. Each of these areas and paths between these areas and the site area are discussed separately with regard to sidewalks, crosswalks, and pedestrian crossing time. Discussions earlier in this report center on existing conditions and walking time to various destinations

Aquarium Station/Waterfront Area

The Aquarium Station/Waterfront Area is served by two major routes to/from International Place. The two routes are as follows:

Figure 18 - Pedestrian Commuter Flow Patterns



International
Place
at Fort Hill

Vanasse/Hangen Associates
Boston, MA

- Along Purchase Street, crossing the High Street, Surface Artery and Atlantic Avenue intersection to Atlantic Avenue northbound to the Aquarium parking garage and Aquarium Station.
- Along Purchase Street to the Surface Artery, then either crossing at East India Street or Milk Street to Atlantic Avenue.

Currently, the pedestrian flow along these two routes are relatively low, but with the development of International Place it is estimated that 560 more pedestrians will use these two routes during the peak commuter hour.

The existing sidewalks on both sides of Purchase Street, Atlantic Avenue, East India Street, and Milk Street are currently adequate to handle the expected pedestrian flow generated by the International Place development. The existing sidewalk on the west side of Surface Road, with the bridge columns from the Central Artery, presents some constraints to smooth pedestrian flow and will influence where pedestrians cross the Surface Artery to reach the transit and parking facilities. However, the sidewalk along the east side of Atlantic Avenue does have more than an adequate walkway width to accommodate all pedestrian demand created by the project traveling between the site and this general area.

Along the two pathways, crosswalk markings are located at all of the signalized intersections in this area to provide clear direction for the pedestrian to cross each intersection. Generally,

it is our opinion that crosswalks are adequately provided along the routes between the sites and this area. A crosswalk will be necessary on High Street at Purchase Street to serve pedestrians immediately adjacent to the project.

Currently the signalized intersections in this area provide some form of pedestrian crossing time with the exception of: Atlantic Avenue at High Street, Surface Artery at State Street, and the Surface Artery and India Street intersection. Intersections which have both exclusive pedestrian actuated timing as well as concurrent non-actuated pedestrian timing are Atlantic Avenue and Milk Street and Atlantic Avenue and East India Street. The intersection of Atlantic Avenue and State Street provides concurrent pedestrian timing while the intersection of Surface Road and Milk Street has an exclusive pedestrian timing. The intersection which does not specifically provide pedestrian signal phases experience pedestrians crossing concurrently with vehicles when a green signal indication is given. Table 38 summarizes the pedestrian timing operations provided at each intersection serving pedestrians between the project site and the Aquarium/Waterfront area.

It should be noted that the Rows Wharf project will include improvements to pedestrian crossing facilities (i.e. crossing markings, signal actuation) at the High Street/Atlantic Avenue intersection.

TABLE 38
PEDESTRIAN TIMING SUMMARY
(AQUARIUM STATION AREA)

Location	Type of Pedestrian Phasing	Time Provided ^{1/}	Cycle Length
Atlantic Avenue/ High Street ^{2/}	None ^{3/}	-	AM - 90 Sec. PM - 100 Sec.
Surface Road/ State Street	None ^{3/}	-	AM - 90 Sec. PM - 100 Sec.
Surface Road/ India Street	None ^{3/}	-	90 Sec.
Atlantic Avenue/ Milk Street	Exclusive & Current Phases	AM - 15 Sec. PM - 14 Sec.	AM - 90 Sec. PM - 100 Sec.
Atlantic Avenue/ State Street	Exclusive & Current Phases	14 Sec.	AM - 90 Sec. PM - 100 Sec.
Atlantic Avenue/ State Street	Current Phases	16 Sec.	AM - 90 Sec. PM - 100 Sec.
Surface Road/ Milk Street	Exclusive Phase	15 Sec.	AM - 90 Sec. PM - 100 Sec.

^{1/} Time provided on the existng timing chart.

^{2/} Pedestrian crossing facilities to be improved in conjunction with Rows Wharf project.

^{3/} Pedestrians cross on green signal indication.

Overall, the Aquarium Station/Waterfront Area includes adequate sidewalks and crosswalks to handle the additional peak hour pedestrian flows generated by the project. Pedestrian signal timings at the signalized intersections may require adjustments in the future which requires monitoring the conditions. Also, a balance must be struck in regards to pedestrian and vehicular right-of-way. As planned under the Rows Wharf Development, the intersection of High Street, Surface Road and Atlantic Avenue will be improved for pedestrian crossings. The proponent of International Place will

want to ensure that a safe pedestrian environment is provided surrounding the project and include the installation of crosswalks on High Street at Purchase Street.

South Station Area

The pedestrian flows generated by International Place which use South Station area are generally served by two routes. The two routes are as follows:

- Along Oliver Street to Purchase Street then to Summer Street, and
- Along Oliver Street to Purchase Street crossing the pedestrian bridge to Atlantic Avenue onto South Station.

It is estimated that approximately 1,780 pedestrians will use these two routes to and from International Place during the commuter peak hours. Currently, sidewalks are provided on all the streets in this area. At present, Purchase Street was observed to carry relatively low pedestrian flows toward South Station. Many people use Congress Street and cross to Atlantic Avenue to get to South Station. A relatively large number of pedestrians use the pedestrian bridge to crossover to Atlantic Avenue, however they are typically destined for across the Fort Point Channel. Most pedestrians walking between South Station and the financial district currently cross Purchase Street and Atlantic Avenue at Summer Street (Dewey Square).

With respect to current flows and sidewalk widths, the additional pedestrians on Purchase Street will not encounter any major "capacity" impact along the Purchase Street sidewalks due to sufficient width and currently low volumes. Although Atlantic Avenue is expected to carry more pedestrians to the South Station area, sidewalk conditions are expected to be able to accommodate the flows, particularly the wide plaza type area in front of the Federal Reserve Bank where relatively high pedestrian flows can be expected. Improvements have been proposed to upgrade the pedestrian bridge between Atlantic Avenue and Purchase Street which in turn, will improve the pedestrian flow along this area, and make for a more convenient and safer connection to South Station from the project site in specific and the financial district in general. The bridge project also eliminates the need to stop vehicular flow along the two major arteries to allow pedestrians to cross.

At all the major signalized intersections, crosswalks are provided for pedestrian crossing. Crosswalks are also provided at the pedestrian actuated signals currently located on Purchase Street and Atlantic Avenue. The two locations where crosswalks are not present are at the unsignalized intersections of Purchase Street and Oliver Street and Purchase Street and Pearl Street. With the development, significant pedestrian flows can be expected at these crossing locations and as a result, crosswalks should be provided on these two intersections.

Each signalized intersection in this area was analyzed to determine what level of pedestrian crossing time was provided. The results are summarized in Table 39.

TABLE 39
PEDESTRIAN TIMING SUMMARY
(SOUTH STATION AREA)

Location	Type of Pedestrian Phasing	Time Required To Cross ^{1/}	Cycle Length
Congress Street/ Purchase Street	Concurrent Phase	23 Sec.	90 Sec.
Congress Street/ Atlantic Avenue	Concurrent & Exclusive Phase on one Movement	26 Sec.	90 Sec.
Atlantic Avenue/ Summer Street	Concurrent Phase	19 Sec.	100 Sec.
Purchase Street/ Summer Street	Concurrent Phase	19 Sec.	100 Sec.

^{1/} Time required to cross is the time required to cross the most critical section of the intersection.

From the table, all the signalized intersections have concurrent pedestrian crossing with the intersection of Congress Street and Atlantic Avenue having both concurrent and exclusive pedestrian actuated phases. Again, these intersections may require actions such as adjustments to existing signal timing and as such should be regularly monitored by the City. Although relatively large portions of the signal cycles include pedestrian phases, the Dewey Square intersections continue to be affected by pedestrian "interference".

Planning studies^{1/} have proposed major pedestrian improvements in this area designed to reduce the conflicts between pedestrians and vehicular flow. Although, probably a long-term improvement, the City has made a commitment to improving the pedestrian environment making this a realistic improvement project.

Government Center/Financial District

The International Place development will generate approximately 2,100 additional pedestrians walking between the site and this area during the peak commuter hour. This area is made up of several pathways which will carry the pedestrian flows to and from the transit stations, express bus stops, and parking areas. Four of these pathways are summarized below:

- o Along Oliver Street to High Street, then Congress Street to Matthew Street and onto Federal Street,
- o Along Oliver Street to Federal Street,
- o Along Oliver Street to Milk Street, and
- o Along Oliver Street to Kilby Street then onto State Street and either use New Congress Street or Quincy Market to Government Center.

As observed in the inventory period, all streets in this downtown area generally provide wide enough (5 to 15) sidewalks to accommodate the pedestrian flows, and no significant congestion during the peak commuter hour was observed. Although not in our

^{1/} Dewey Square TSM Study, Draft Report, unpublished, 1984.

study area, the Congress Street/State Street intersection is a location where significant pedestrian volumes occur. However, the sidewalks and storage areas at this location have been upgraded to accommodate existing and projected flows.

The sidewalks in the study area between the site and the financial district are currently in good condition and of sufficient width to accommodate the additional pedestrian flow. Due to the development projects which have occurred over the past ten years and are continuing major improvements have been made to sidewalk conditions and capacity. With International Place, the sidewalks will continue to be adequate to handle the added flows since pedestrians will distribute on four or more pathways in this area. The four pathways identified will provide a choice to the pedestrians resulting in each street in the area carrying some portion of the estimated 2,100 pedestrians generated by the project.

Generally, crosswalks are provided at all of the intersections along the pathways in this area. With these crosswalks, the pedestrians are given a clear direction for crossing the streets. One area away from the site where crosswalks were not observed but should be added is State Street at Kilby Street.

The signalized intersections in this area have been reviewed to identify the pedestrian crossing time provided. Currently, these intersections are running on a master system controlled by a computer located in Boston City Hall. Under the system master

control, all intersections in this study area have exclusive pedestrian actuated phases built in to each cycle. However, concurrent non-actuated walk phases are also provided and observations indicate very little exclusive operation occurs. Table 40 summarizes the exclusive timing provided on each intersection in the study area. As can be seen, 15 seconds of exclusive time is provided at each intersection. This combined with concurrent timing built into the cycle should adequately serve pedestrians.

TABLE 40
PEDESTRIAN TIMING SUMMARY
(FINANCIAL DISTRICT/GOVERNMENT CENTER AREA)

Location	Type of Pedestrian Phasing	Time Provided ^{1/}	Cycle Length
Congress Street/ Federal Street	Exclusive Pedestrian	15 Sec.	AM - 70 Sec. PM - 90 Sec.
Congress Street/ High Street	Exclusive Pedestrian	15 Sec.	AM - 70 Sec. PM - 90 Sec.
Federal Street/ Pearl Street	Exclusive Pedestrian	15 Sec.	AM - 70 Sec. PM - 90 Sec.
High Street/ Pearl Street	Exclusive Pedestrian	15 Sec.	AM - 70 Sec. PM - 90 Sec.

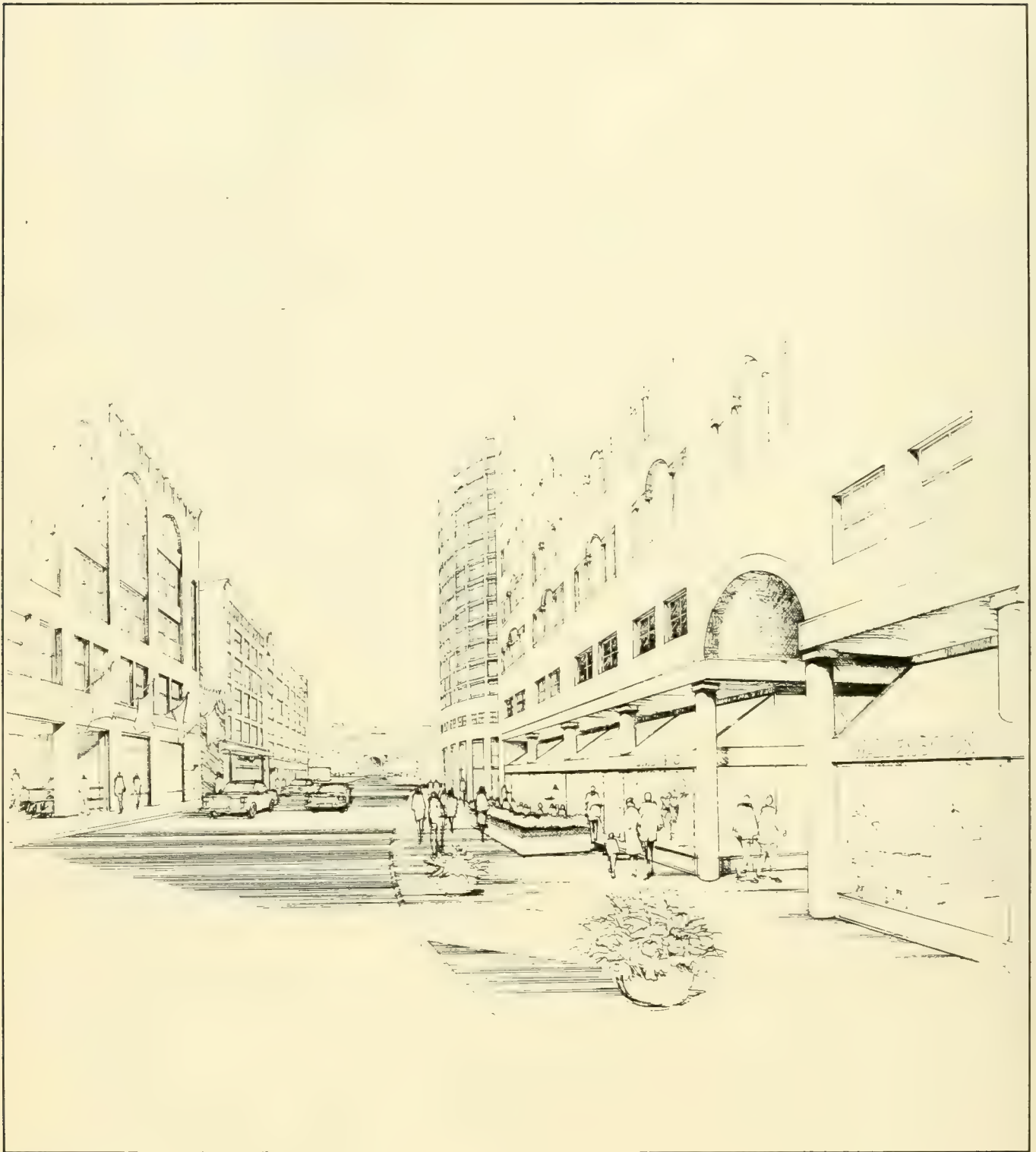
^{1/} Time provided on the exclusive pedestrian phase.

During the noon period, a peak in pedestrian activity is also expected due to employee lunch, shopping, and personal business trips. As a result, the peak pedestrian flow is expected to have a different directional and spatial orientation than the commuter peak flow patterns which will tend to be less concentrated flows.

Overall, the project's impact on existing pedestrian flow will be minimal in the vicinity of the site as existing pedestrian volumes are relatively low. The project site itself is being designed with pedestrian flow seriously considered and as a result, sidewalks with a minimum 15-foot width to accommodate future pedestrian flows are being planned surrounding the site. With two separate elevator cores and six major pedestrian access/egress points connecting to both cores, pedestrian flows within the complex will tend to be relatively smooth and spread out. Although peak hour pedestrian flows will be significant in total, the large entry ways allow for easy pedestrian queuing while having a minimal impact on pedestrian flow along the sidewalk. Figures 19 through 22 present illustrations of planned entrances to the project from the three surrounding streets.

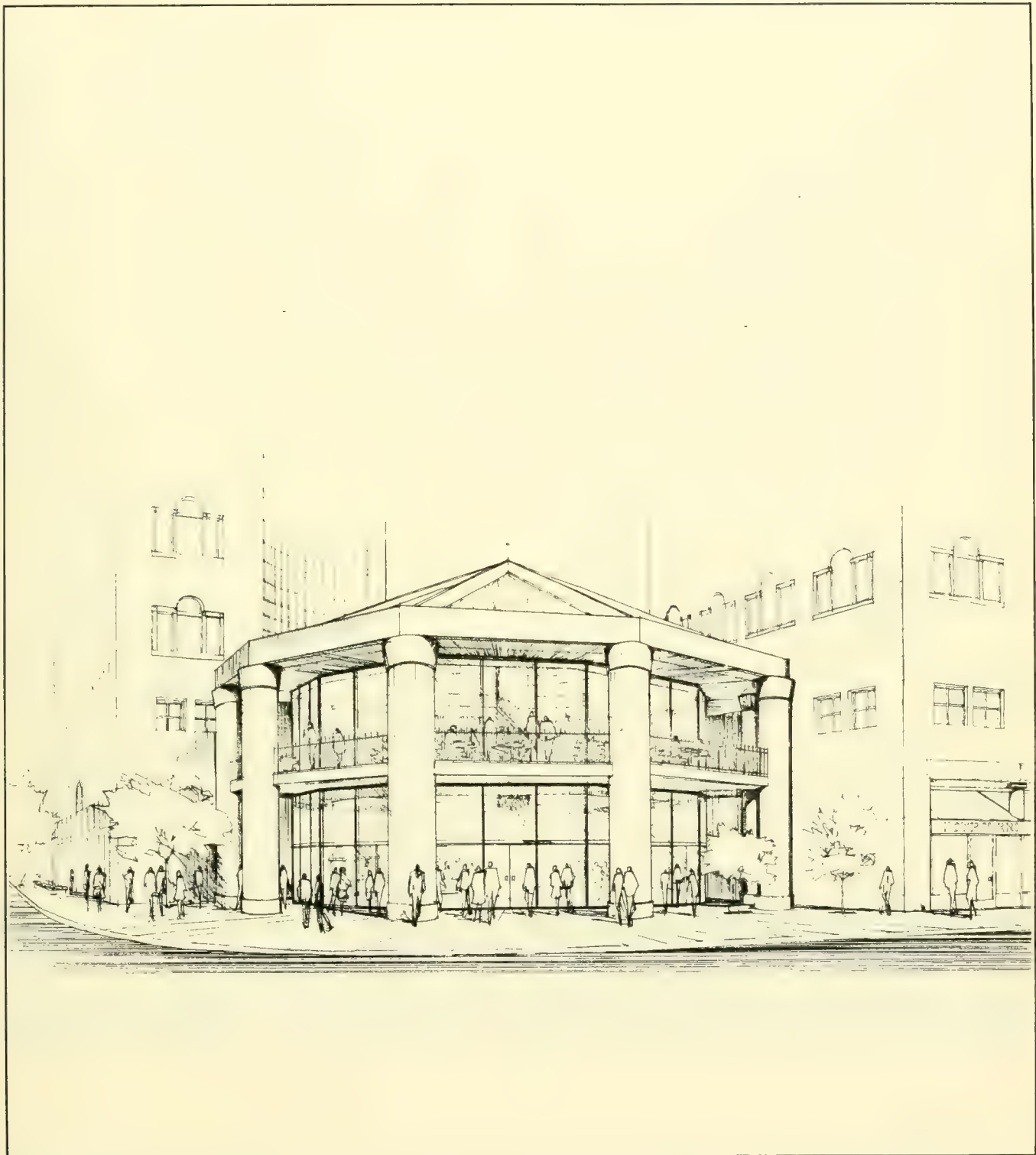
On the streets immediate to the project, well marked crosswalks should be provided on High Street at Purchase Street and at Oliver Street, on Oliver Street at Purchase Street and at High Street. Different textured material should be considered to clearly delineate the walking path . Away from the site, adequate crosswalks are generally provided at all intersections with the few exceptions previously noted. The city should continue their program of providing crosswalks at all major intersections downtown. Also, periodically, pedestrian phase timings should be reviewed for possible adjustment, balancing the needs of both pedestrians and vehicles.

Figure 19 High Street Pedestrian Level



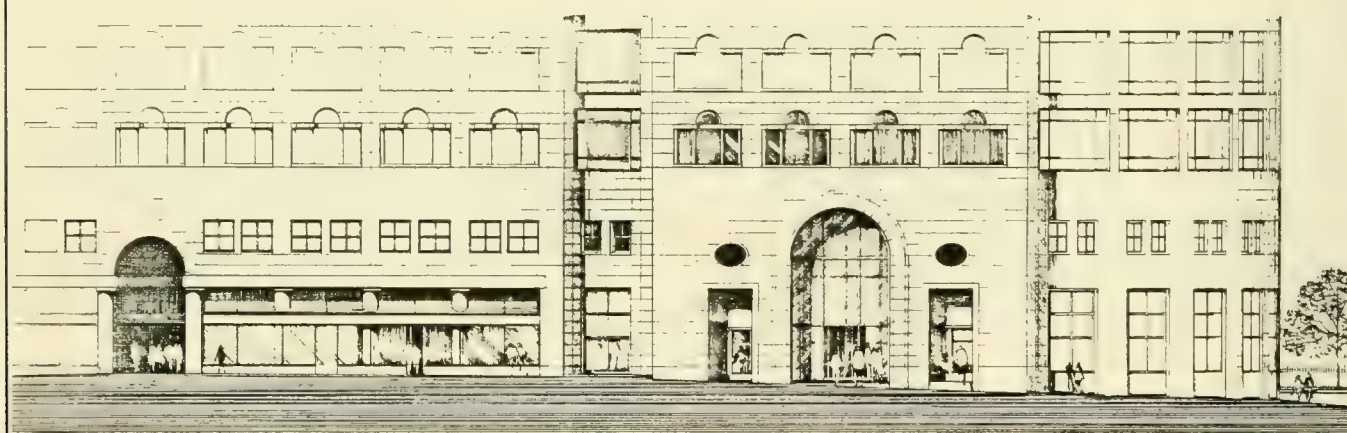
International
Place
at Fort Hill

Figure 20 Main Entrance at High and Oliver Streets



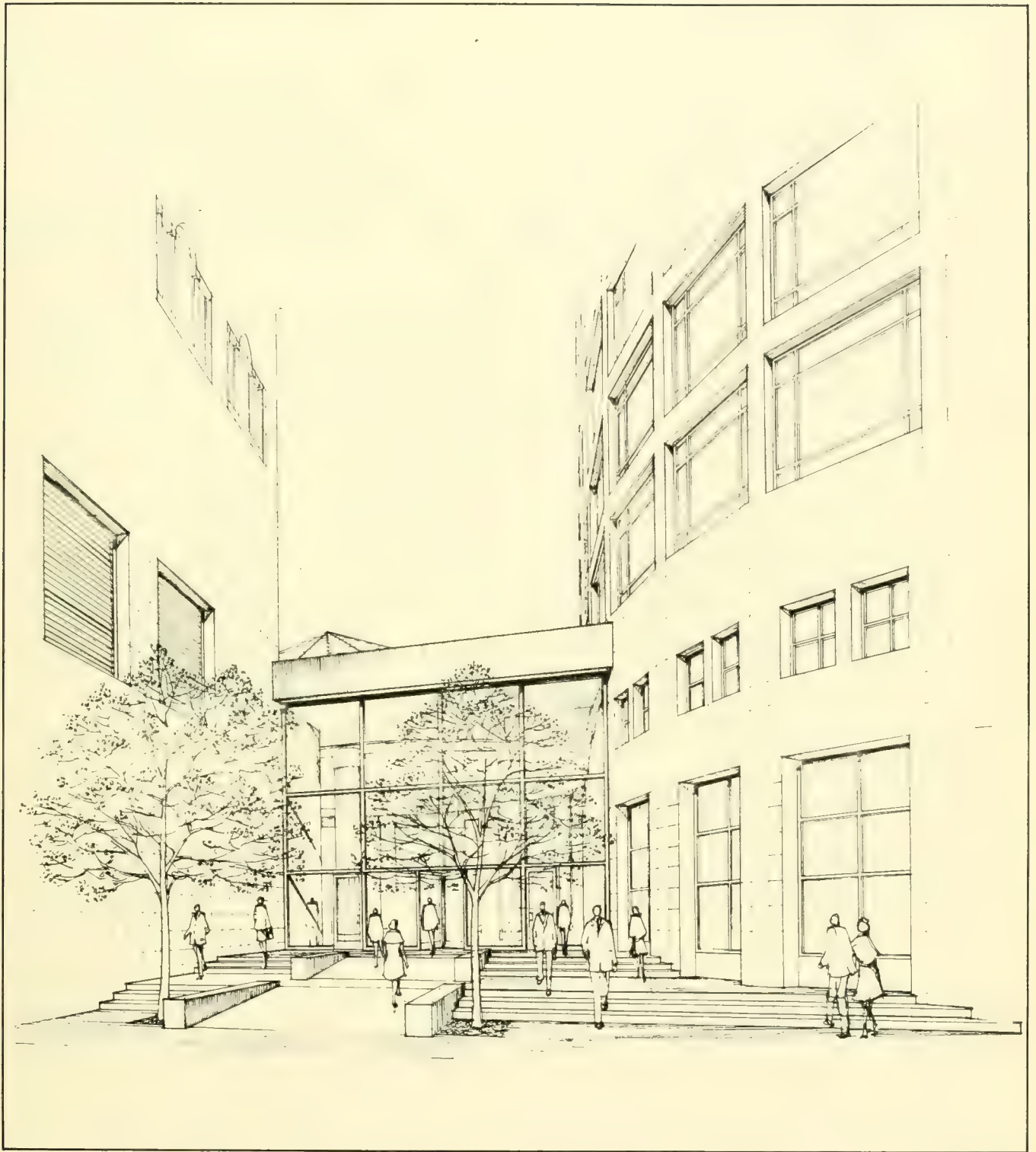
International
Place
at Fort Hill

Figure 21 Oliver Street—Pedestrian Level



International
Place
at Fort Hill

Figure 22 Purchase Street Courtyard Entry



International
Place
at Fort Hill

SUMMARY OF PROJECT IMPACTS

The previous sections have described the transportation system characteristics, the projected travel demands generated by the proposed International Place, and its impact on the various components of the transportation system. The following paragraphs summarize the results of the analysis.

- The International Place office/retail complex is anticipated to generate a total of 26,780 daily person-trips with 13,390 entering and 13,390 exiting the site.
- Although many person-trips will be generated, a relatively small number of vehicle-trips are anticipated as 71 percent or 16,518 of the total person-trips are expected to be by transit or the walk mode. This results in a total of 4,656 daily vehicle-trips with 2,328 entering trips, and 2,328 exiting trips. The figure includes taxis and delivery vehicles as well as employees and visitors.
- Peak hour vehicle-trip generation represents approximately 17 to 18 percent of the daily project figures. This results in an estimated 770 vehicle-trips during the AM peak hour and 819 vehicle-trips during the PM peak hour.
- The projections have been made assuming an increased supply of parking exists convenient to the site. If the supply does not materialize to meet demands created by this project and other

projects in the area, then a shift from private auto to ride-sharing transit modes will occur resulting in fewer vehicle-trips than projected. The analysis has shown that given the future transit improvements designed to increase capacity and improve reliability, a residual physical capacity is available to accommodate some diverted commuters.

- The project is anticipated to have a relatively minimal impact on peak hour travel conditions due to several factors. The project's proximity to the Central Artery will minimize the number of project related vehicles added to the local street system. In addition, the spatial location of available parking sites will tend to spread the site related trips over the entire network. Planning studies, which are either currently underway or have been completed at a preliminary level, have proposed further modifications to improve the transportation system in the Financial District/South Station area. These modifications, including reversing the directional flow on High Street and relocating the High Street off-ramp, which have been included in this analysis as part of the 1990 roadway network.
- Intersections which are projected to operate at low levels of service (LOS "E") during the peak hour under the 1990 No-Build condition will continue to do so at Full Build out. International Place has a small impact on the operating conditions at these intersections during the peak hour as the volume to

capacity ratio is marginally increased. The added traffic as a result of the project will increase vehicle queues and delays to a small degree based on the small V/C ratio changes.

- Intersections along the High Street and Franklin Street corridors are anticipated to operate at high levels of service and be minimally impacted by the project.
- Although several Central Artery on- and off-ramps are expected to experience net added traffic volumes as a result of the project, is not anticipated to significantly affect the operations of these various on- and off-ramps with the exception of the Northern Avenue northbound on-ramp. The Northern Avenue on-ramp which currently experiences substantial queues of 250 feet, is expected to experience queues in the 1990 No-Build condition up to 850 feet. The 3 percent increase in ramp traffic due to the project, in conjunction with the scheduled traffic control improvements in this location will combine to minimize any increase in vehicle queues on this ramp. However, theoretically, the added 16 vehicles could increase the queue by 300 feet.
- Although a large number of pedestrians are anticipated as a result of the project (i.e. 4,400 during peak commuter hour), pedestrian access into and out of the site is being designed to meet the demands through multiple entry/exit points, wide sidewalks, and large courtyard type entry areas. Street crossing areas immediately adjacent to the project site will

have to be clearly defined. The project is being designed to attract and to accommodate expected pedestrian volumes. In addition, transportation improvements generated by the Dewey Square planning study include providing an improved connection from Atlantic Avenue to Purchase Street and creating a better pedestrian environment. The Rowes Wharf project will also improve the pedestrian crossing environment from Atlantic Avenue to High Street.

- Although the project will result in a relatively large number of new transit passengers, the analysis indicates that with the scheduled capacity improvements on the subway system, the additional riders generated by this project as well as other background growth projects can be accommodated.

MITIGATION MEASURES TO THE PROJECT

The transportation analysis has shown that the travel demand generated by International Place can generally be accommodated on the study area transportation system. This is due to several reasons including the close proximity to both the Central Artery and MBTA subway, express bus and commuter rail systems. In addition, the availability of parking will ultimately play an important role in influencing travel by mode. However, to ensure that the impact on the network is minimal, several mitigation measures are offered which are designed to increase the efficiency of the existing roadway capacity and reduce vehicular demands. Mitigation Measures, both related and unrelated to the project, which should be pursued are described below.

A. PROJECT RELATED

Vehicle Demand/Reduction

- It is proposed that, within the garage facility, clearly designated spaces will be reserved for ridesharing vehicles to encourage increased participation and thus reduce vehicle-trips. Caravan, the State's ridesharing agency, which matches interested riders with existing vanpools and helps to initiate in-house programs, will be consulted. Information on ridesharing will be made available to tenants of the building.

- Subsidizing MBTA passes and a vanpool program, can be effective in increasing such ridership. These options are being pursued by the proponent and will be pursued with individual building tenants as well.
- The proponent and MBTA have agreed that a member of the MBTA planning staff will advise the project design team on public transportation coordination.
- The proponent will work with tenants to market all alternative modes of travel including the commuter rail and boat systems.
- The proponent will work with major tenants to encourage flexible or staggered work hours. Observations of both vehicular traffic and transit ridership indicates that a certain amount of peaking occurs within a 15 to 30 minute period. Shifting worker arrival or departure times 15 to 30 minutes from the "normal" times would reduce the project's impact on this peaking characteristic. In addition, the transportation system would have more residual capacity available during these non-peak periods within the commuter hour to better accommodate the demands.

Site Specific Design/Operations

Several mitigating actions have been identified and already incorporated in the design of the International Place project. These actions which are outlined here will ensure that traffic flow demands are adequately accommodated on the local street network surrounding the project.

- The design of the garage has been modified to include long entrance drives in order to avoid a vehicle queue onto Purchase Street. Also, a single exit drive has been designed in an effort to control vehicle movement onto Purchase Street.
- All truck docks will be located on-site and underground to avoid disrupting traffic flow on Purchase Street.
- As demonstrated elsewhere in the City, private security personnel will be provided to monitor and control vehicular traffic flow in and out of the garage.

Pedestrian/Bicycle Facilities

- Sidewalks surrounding the site will be approximately 15 feet minimum to ensure adequate pedestrian flow and queuing.
- Pedestrian street crossing location immediately surrounding the site will be clearly marked on High Street and Oliver Street.
- A convenient, secured bicycle parking facility will be incorporated into the final design of the project.

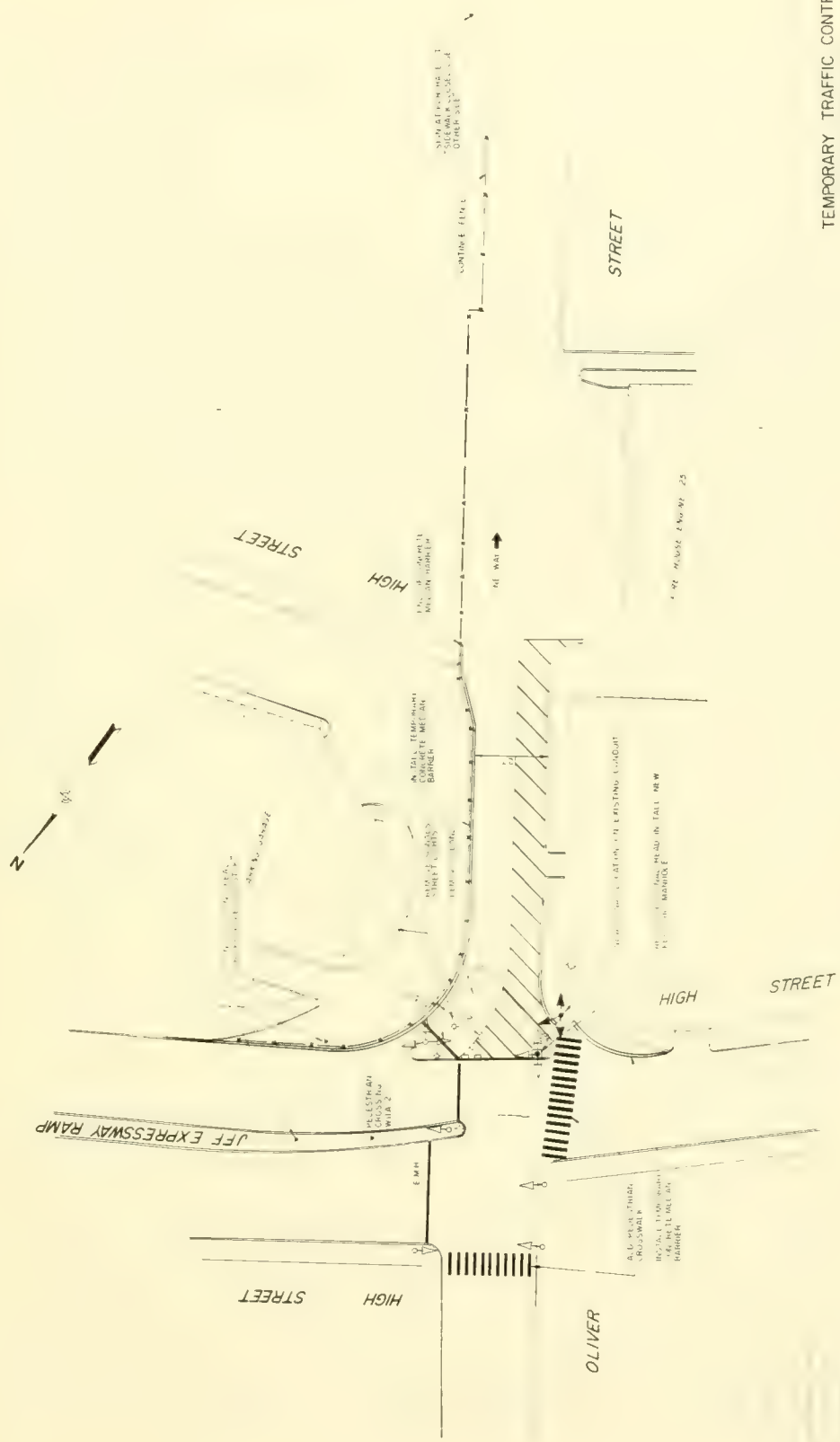
Roadway

- To ensure safe operating conditions along Purchase Street in front of the site, on-street parking should be prohibited.
- There should be curb space designated on either Oliver Street or High Street for taxis as well as small vehicle delivery service. A minimum of 100 feet of curb space should be allocated for each of these vehicle-trips.

- Oliver Street should be designed as one-way eastbound to ensure a smoother flow of vehicles between the Central Artery and Purchase Street. It will also prevent motorists exiting the Purchase Street ramp from turning immediately right and conflicting with Purchase Street through traffic.
- The proponent will continue to work with the State in planning for the High Street southbound off-ramp relocation. Design and construction of the project will be coordinated with the design and construction of the ramp relocation with the objective of maintaining traffic flow on local streets during construction.
- The proponent is developing and will implement a temporary traffic control plan for the construction period of the project. General guidelines have been developed as well as a concept for the High Street/Oliver Street intersection during construction. The plan to date is as follows:
- Construction worker traffic, although typically not coinciding with peak hour flows, should be controlled by requiring workers to park across the Fort Point Channel and encourage the use of public transit. On-street parking surrounding the site will be prohibited. There may be room on-site to park approximately 100 cars, however, over the long-term, workers will be forced to park at other locations off-site.

- o Vehicular traffic is to be maintained at all times on Oliver Street and High Street. It is currently anticipated that traffic flow on Purchase Street will also be maintained at all times. However, with respect to the relocation of this ramp, there may be short periods where it would be more desirable to reroute traffic from Purchase Street to High and Oliver Streets. Police officer control would be required at the High Street/Oliver Street intersection.
- o Police officers will be present during construction to help control pedestrian traffic, vehicular traffic on the surrounding roadways, and site related truck traffic.

As stated, a concept plan for temporary traffic control during the construction period has been prepared for the intersection of High Street/Oliver Street. The concept has been reproduced in Figure 23. The plan includes designating Oliver Street as one-way towards Purchase Street, maintaining full fire apparatus access, removing the existing traffic island and relocating the affected traffic signal postheads, installing a temporary concrete median (Jersey Barrier) along the east side of Oliver Street to a point approximately 150 to 175 feet beyond the exit ramp, a construction fence is to be placed behind the concrete median and surround the entire site, signing is to be placed on the exit ramp as a warning to motorists, signing for pedestrian traffic control at the intersection of Purchase Street/Oliver Street, and marking the



TEMPORARY TRAFFIC CONTROL PLAN
DURING CONSTRUCTION

INTERNATIONAL PLACE
HIGH STREET AT OLIVER STREET
BOSTON, MASSACHUSETTS

		VANASSE HANGEN ASSOCIATES, INC. 100 STATE STREET, SUITE 200 BOSTON, MASSACHUSETTS 02109 TEL: 617/552-1234 FAX: 617/552-1235	
DATE	NOV 27 1984	PROJECT	RECONSTRUCTION OF HIGH STREET
BY	J. H. B.	DESIGNED BY	J. H. B.
CHECKED BY	J. H. B.	APPROVED BY	J. H. B.
SCALE	AS SHOWN	PROJECT NO.	788

Figure 23

pavement to show no access areas and crosswalks. This plan as been reviewed by the City of Boston and modified to address the traffic department's concerns.

The temporary traffic control planning to date indicates the the control plan will not effect traffic flow conditions, most importantly, during the peak travel hours. Flow is to be maintained on surrounding streets. The only operation change would be to designate Oliver Street one-way towards Purchase Street which does not affect the majority of flow.

- When the High Street off-ramp is relocated, police officer control will likely be required to insure safe accommodation of diverted ramp traffic during the three to four week period when both the existing and new ramp are closed to traffic. Post Office control may also be required at the Dock Square and Dewey Square C.A. exits during this period as well.

B. UNRELATED TO THE PROJECT

Traffic Flow Operation

- Signalization optimization improvements and adjustments will be necessary to accommodate the projected traffic flow patterns and pedestrian demands should continue to be pursued by the City and State. These adjustments will be necessary along the Purchase Street, Atlantic Avenue and High Street corridors in the future as general travel volumes and patterns change.

- Mitigation measures which have been recommended in other environmental studies in the vicinity of this project site should be pursued. These include major transit improvements at South Station, Dewey Square, ferry service along the waterfront and the various MBTA subway improvements. Traffic engineering and roadway improvements currently being planned include signaling Northern Avenue at Atlantic Avenue and implementing the Dewey Square improvement program. Restricting curbside parking along Purchase Street and Pearl Street should continue to be strictly enforced during the AM and PM peak hours. This restriction will be increasingly needed as flows increase along these two streets.
- Recognizing both the current and projected traffic conditions on the City's major highways as well as the economic importance of Boston to the region, the State is pursuing major highway improvement projects in the City (i.e. Northern Avenue Bridge, Central Artery, Seaport Road). However, implementation of these improvements will take time. For example, major reconstruction of the Central Artery may be ten years away. In the meantime, there may be feasible, traffic management actions which can be taken to improve flow on both the Central Artery and adjacent downtown arterials. It is recommended that a traffic management study of the Central Artery be undertaken by the State with the goal of improving and managing downtown traffic flow until the reconstruction project begins.

Pedestrians

- Improvements planned or recommended as part of the Dewey Square planning study and the Rowes Wharf project should be pursued. These improvements are to include a new pedestrian bridge crossing from Atlantic Avenue to Purchase Street (within several hundred feet of the site) and a projected pedestrian crossing located at the High Street/Atlantic Avenue intersection. In addition, improvements at Dewey Square will minimize the vehicle-pedestrian conflicts which currently take place affecting overall intersection capacity.
- As new development occurs in the Financial District, the City should continue to emphasize the importance of pedestrian improvements as part of the development. The result will be a continued program for upgrading the overall downtown pedestrian system.

Parking

- The City should pursue and continue to implement the recommendations outlined in the most recent downtown parking survey. These recommendations have included major increases in supply at South and North Stations, adjustments in the parking freeze bank, and development of parking management program for now uncontrolled sections of the City. These recommendations, as pointed out in the parking study, are required to meet the forecasted travel demands generated by all of the anticipated

development through 1990. As stated in the Boston Parking Study, implementation of supply and management actions, if completely successful would reduce the projected city 1990 deficit of 22,600 to approximately 700.

- For modifications to the existing parking system to occur, adjustments to the parking freeze are necessary. The City is now working with DEQE in receiving approval for the modifications to the freeze. Before final approval can be given, a study of the air quality impacts as a result of the modifications must be completed. Final concurrence with the modified transportation control plan will also have to be reviewed from the U.S. Environmental Protection Agency. To date, according to the Boston Air Pollutin Control Commission (BAPCC), the process is 25 percent complete.
- In the event that major parking supply improvements are not implemented, there will likely be a more substantial shift to other modes of travel (i.e. ridesharing, transit) than was discussed in detail earlier in this report. The analysis has shown that with future transit improvements affecting both line capacity and reliability, the additional shift of riders can be accommodated. However, as discussed below further improvements to transit would be desireable.

Transit

- The MBTA must continue to advance the overall upgrading and improvement plans for all aspects of its system. A critical

area will be the acquisition of new rail cars and the refurbishing of existing vehicles. These improvements will be necessary to meet the projected transit demands created by all downtown developments through 1990 and beyond.

- Planning studies should be conducted for the subway lines identified in this study which by 1990 will experience ridership levels approaching capacity. Mechanisms should be developed as a result of these planning studies which will help the MBTA meet the increasing demands. This will become a more critical need in the event the City does not pursue all the recommended parking improvements. It is important to note, however, that with currently planned improvements, residual capacity will exist in 1990 and the transit system will be able to physically accommodate downtown transit demands even with the additional shift (recognizing that periods will exist during the peak hour when standees will exist and passengers will have to wait on the platform for an available train.
- One transit improvement which is not currently in the program, but one identified as a result of the DEIR review process, is to increase the frequency of the Blue Line during the peak hour. This could increase line capacity to 9,730 and as a result, reduce line v/c from 0.87 to 0.79 under 1990 Build condition.

- As the Financial District continues to develop and generate additional transit passengers, it may be appropriate to also modify local bus patterns to improve connections between the regional system (i.e. South Station) and the development corridors. This will become increasingly important with the completion of the South Station Multi Modal Center project. A loop type system may be appropriate. The situation should continue to be closely monitored by the MBTA and modifications or additional service provided when appropriate.

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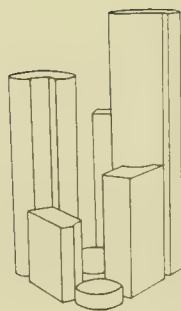
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Air Quality



V. Air Quality Analysis for International Place, Boston

for

The Chiofaro Company
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Boston, Massachusetts 02109

by

HMM Associates
336 Baker Avenue
Concord, Massachusetts 01742

The following Air Quality report supplants the initial analysis submitted to the Boston Redevelopment Authority as part of the May, 1984 EIR. It is the same report submitted to the Massachusetts Secretary of Environmental Affairs office as the Final EIR in compliance with G.L., Chapter 30, Section 62-62H and the regulations implementing the Massachusetts Environmental Protection Agency (MEPA). As such, it incorporates the comments received from public agencies and private organizations, including those from the BRA. Further responses to BRA comments are contained in the Comments and Responses section of this Report.

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5.3 AIR QUALITY ANALYSIS

5.3.1 Introduction

The purpose of the Air Quality Analysis is to determine impacts of International Place on local air quality. The following issues are addressed:

1. Microscale Analysis - Impact on local air quality from project related traffic.
2. Effect of Air Flow Modifications on Pollutant Dispersion.
3. Construction Related Impacts (Fugitive Dust)
4. Handling and Removal of Asbestos Material.

5.3.2 Microscale Analysis

Objective

The objective of this analysis is to verify that with construction of International Place the Massachusetts and National Ambient Air Quality Standards (NAAQS) for carbon monoxide (CO) will be attained and maintained. The standards, established by the Federal Clean Air Act, are designed to protect both public health and welfare. To demonstrate compliance, it is necessary to identify those areas of human activity (sensitive receptors) exposed to maximum air pollutant levels from motor vehicle emissions in the project area. Using air quality modeling techniques, CO levels are estimated at these sensitive receptors for all project alternatives for the present and future years. Comparison of projected pollutant levels to the NAAQS permits evaluation of whether motor vehicle emissions will pose a threat to public health or welfare.

The microscale analysis will address the following issues in the order presented:

- i) Background levels (existing and future 1990).
- ii) Calculation of study area CO emissions.
- iii) CO impacts at sensitive receptors from roadway emissions.
- iv) CO impacts of the on-site parking facilities.
- v) Plume trapping below the elevated Central Artery.
- vi) Cumulative CO impacts at sensitive receptors from all sources.

Pollutant Sources and Effects

Of the six pollutants regulated by the NAAQS, four are emitted by motor vehicles or formed from their emissions: CO, nitrogen oxides (NO_x), ozone (O_3), and lead (Pb). Carbon monoxide is used in the microscale analysis as an indicator of roadway air pollution levels, since it is the most abundant and persistent pollutant emitted by motor vehicles. Further, its nonreactive properties allow pollutant transport and dispersion to be modeled.

The adverse health effects of carbon monoxide are a result of its combination with blood hemoglobin to form carboxyhemoglobin (COHb). This compound interferes with the life-sustaining transfer of oxygen from the lungs to the body tissues and the return of carbon dioxide from the tissues to the lungs. The presence of relatively small amounts of CO results in significant interference with essential cardiovascular-respiratory functions. Relatively brief exposure to high levels (over 40 ppm) can impair time interval discrimination, visual acuity, and other psychomotor functions.

National Ambient Air Quality Standards (NAAQS) for carbon monoxide have been set by the U.S. Environmental Protection Agency (EPA), and are presented in Table 5.3.1. Standards for the Commonwealth of Massachusetts are identical to the Federal standards. The primary standards are intended to protect the public health, while secondary standards are designed to protect the public welfare from any known or anticipated adverse effects. The target date for attainment of national primary and secondary standards in Massachusetts is December 31, 1987. Identical for primary and secondary, the CO standards set a maximum concentration of 35 parts per million (ppm) for a one-hour period, and 9 ppm for eight hours, each not to be exceeded more than once per year. The EPA is currently reviewing the scientific, technical, and medical basis for these standards.

Background Air Quality

Any microscale analysis requires an estimate of "background" air quality levels. Background is defined as the CO concentration from all sources, except the major roadways that cross at the intersections being analyzed. Background levels of CO for 1984, in downtown Boston, have been determined by the Massachusetts Department of Environmental Quality Engineering (DEQE)* to be 5.0 ppm (one-hour average) and 3.0 ppm (eight-hour average). These values are consistent with DEQE's CO background policy for high-density urban areas.

* "Draft EIR-Rowes Wharf Development", EOEA-#4992, April 1984.

TABLE 5.3.1
MASSACHUSETTS AND NATIONAL AMBIENT
AIR QUALITY STANDARDS (NAAQS)
FOR CARBON MONOXIDE (CO)

Pollutant	Averaging Time	Primary Standards	Secondary Standards
Carbon Monoxide (CO)	8 hours	9 ppm (10 mg/m ³)	Same as Primary
	1 hour	35 ppm (40 mg/m ³)	

NOTE: Standards are not to be exceeded more than once per year.

National Primary Standards: The levels of air quality necessary, with an adequate margin of safety, to protect the public health.

National Secondary Standards: The levels of air quality necessary to protect the public welfare from any known or anticipated adverse effect of a pollutant.

Study Methodology

The technical approach used to predict ambient air quality was approved in advance by the Massachusetts DEQE.* The analysis calculated maximum one-hour and eight-hour CO concentrations at sensitive receptors near five key inter-sections in the program area (as defined in Transportation Studies Section) for three cases:

* Personal Communication, Ms. Heidi O'Brien, Massachusetts Division of Air Quality Control, DEQE, Boston, MA, July 30, 1984 and August 3, 1984.

<u>Case No.</u>	<u>Year</u>	<u>Project Alternative</u>
1	1984	Existing
2	1990	No-Build
3	1990	Full Build

For each case, the EPA Indirect Source Guidelines* technique, supplemented by a set of assumptions consistent with DEQE requirements,** was used to predict CO concentrations for receptor locations adjacent to local roadways. These assumptions include an ambient air temperature of 33°F, and worst case meteorological conditions of Pasquill-Gifford Class D stability, combined with a 1.0 m/s wind speed for peak 1-hour periods, and 1.6 m/s for peak 8-hour periods. The worst case wind direction (which is a function of source-receptor geometry and determined graphically in the EPA Indirect Source Guidelines*) was studied and determined separately for each intersection and case. An initial vertical dispersion of 5.0 m** was assumed. These meteorological data are appropriate for a December day during which peak CO concentrations are expected to occur.

The CO background levels calculated for 1990 were obtained from 1984 values (presented above) of 5.0 ppm (one-hour) and 3.0 ppm (eight-hour) by scaling down for the reduction in motor vehicle emission rates, and scaling up for the overall growth in project area traffic. CO emission rates (see Air Quality Appendix A),

* EPA, Guidelines for Air Quality Maintenance Planning and Analysis Volume 9 (Revised): Evaluating Indirect Sources, Second Printing, EPA-450/4-78-001, Research Triangle Park, NC, September, 1978.

** Personal Communication, Ms. Heidi O'Brien, Massachusetts Division of Air Quality Control, DEQE, Boston, MA, July 30, 1984 and August 3, 1984.

used in this analysis, will decrease 49 percent from 1984 to 1990 in the project area. Peak-hour traffic volumes (see the Transportation Analysis) at the intersections are projected to grow by 40 percent from 1984 to 1990 (without the project). The additional traffic in 1990 from International Place is not reflected in these figures since it is modeled explicitly in the analysis. The resultant 1990 background CO levels were calculated by multiplying fractional increases in traffic by fractional decreases in CO emissions times the 1984 background levels. The results indicate 1990 CO background levels of 3.6 ppm and 2.1 ppm for the one-hour and eight-hour periods, respectively.

The air quality analysis utilized peak one-hour traffic volumes for the design day. Peak eight-hour volumes were calculated by applying the factors shown in Table 5.3.2 to the peak one-hour volumes. These peak eight-hour to peak one-hour ratios were developed from actual traffic counts; supporting traffic data are provided in the Transportation Appendix. The peak hours of the day in the project area occur from 7:30 to 8:30 a.m. in the morning and from 4:30 to 5:30 in the afternoon (see the Transportation Analysis). The peak eight-hour period includes either the peak AM or peak PM hour. Traffic volume data for the intersections analyzed are presented in the Transportation Analysis. Motor vehicle emissions were calculated with the EPA MOBILE2 computer program,* and are detailed in the Air Quality (AQ) Appendix A. Emission calculations assumed national average values for motor vehicle mix by type. The MOBILE2 national cold/hot start mix default value was used for determining roadway emissions during

* EPA, User's Guide to MOBILE2: Mobile Source Emissions Model, EPA-460/3-81-006, Ann Arbor, MI February, 1981.

TABLE 5.3.2

PEAK 8-HOUR TRAFFIC VOLUME FACTORS
FOR THE PROJECT AREA

Roadway	Ratio of Average Hour of the Peak 8-Hour to the Peak 1-Hour
Oliver Street	0.59
Atlantic Avenue	0.79
Surface Artery	0.70
Congress Street	0.68
Purchase Street	0.70
At Congress Street	
Purchase Street	0.75
At Oliver Street	
High Street	0.67
International Place	0.75
Access Drive	
Northern Avenue	0.73

the peak eight-hour period. A mix with a higher cold start percentage for the commuter rush hour was used to represent the peak one-hour period (see AQ Appendix A). In addition, the Massachusetts registration distribution for light duty vehicles, light duty trucks, and heavy duty trucks* was employed, along with actual travel speeds for vehicles approaching study area intersections (see the Transportation Analysis). Emission rates used in this analysis assume a statewide Inspection and Maintenance (I&M) Program starting in 1984, with a 15 percent stringency factor, and without mechanic training*.

International Place will be located in the area bounded by Purchase, High, and Oliver Streets. Access into the site, by car and delivery trucks, will be off Purchase Street, midway between High and Oliver Streets. The access drive is divided in two so that cars have a

* Personal Communication, Ms. Heidi O'Brien, Massachusetts Division of Air Quality Control, DEQE, Boston, MA, July 30, 1984 and August 3, 1984.

separate driveway as do delivery trucks. Five intersections within the study area (defined in the Transportation Analysis) were identified for the Air Quality Study:

1. Atlantic Avenue and Surface Artery,
2. Purchase Street and Congress Street,
3. Purchase Street and International Place Access Drive,
4. Purchase Street and Oliver Street,
5. Atlantic Avenue and Northern Avenue.

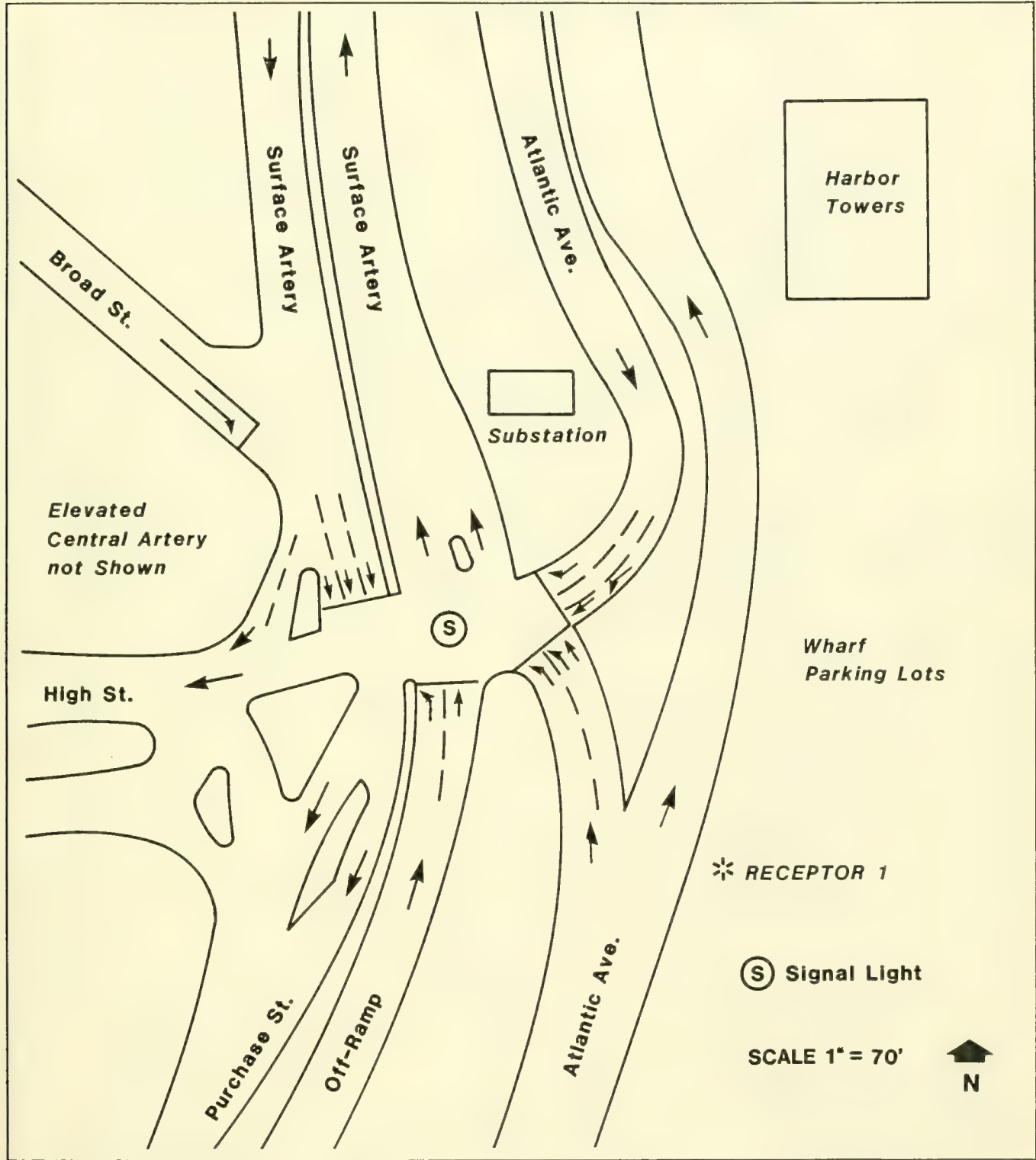
These intersections were selected by DEQE as they are intersections which are predicted to have Level of Service D or E during the peak hour in the design year (1990).

Since carbon monoxide emissions are greatest at roadway intersections due to vehicle idling, acceleration and deceleration, sensitive receptors in close proximity to "worst case" intersections were selected. The receptor locations were chosen to be consistent with the recommendations in the EPA Guidelines* namely: 1) where maximum carbon monoxide concentrations are likely to occur (i.e., adjacent to intersection vehicle queues), and 2) where the general public is likely to have access. The locations of these receptors are illustrated in Figures 5.1 through 5.7 and described below:

1. Along the east side of Atlantic Avenue at the point the roadway forks to the Surface Artery (same as the Rowe's Wharf EIR),

* EPA, Guidelines for Air Quality Maintenance Planning and Analysis Volume 9, (Revised): Evaluating Indirect Sources, Second Printing, EPA-450/4-78-001, Research Triangle Park, NC, September, 1978

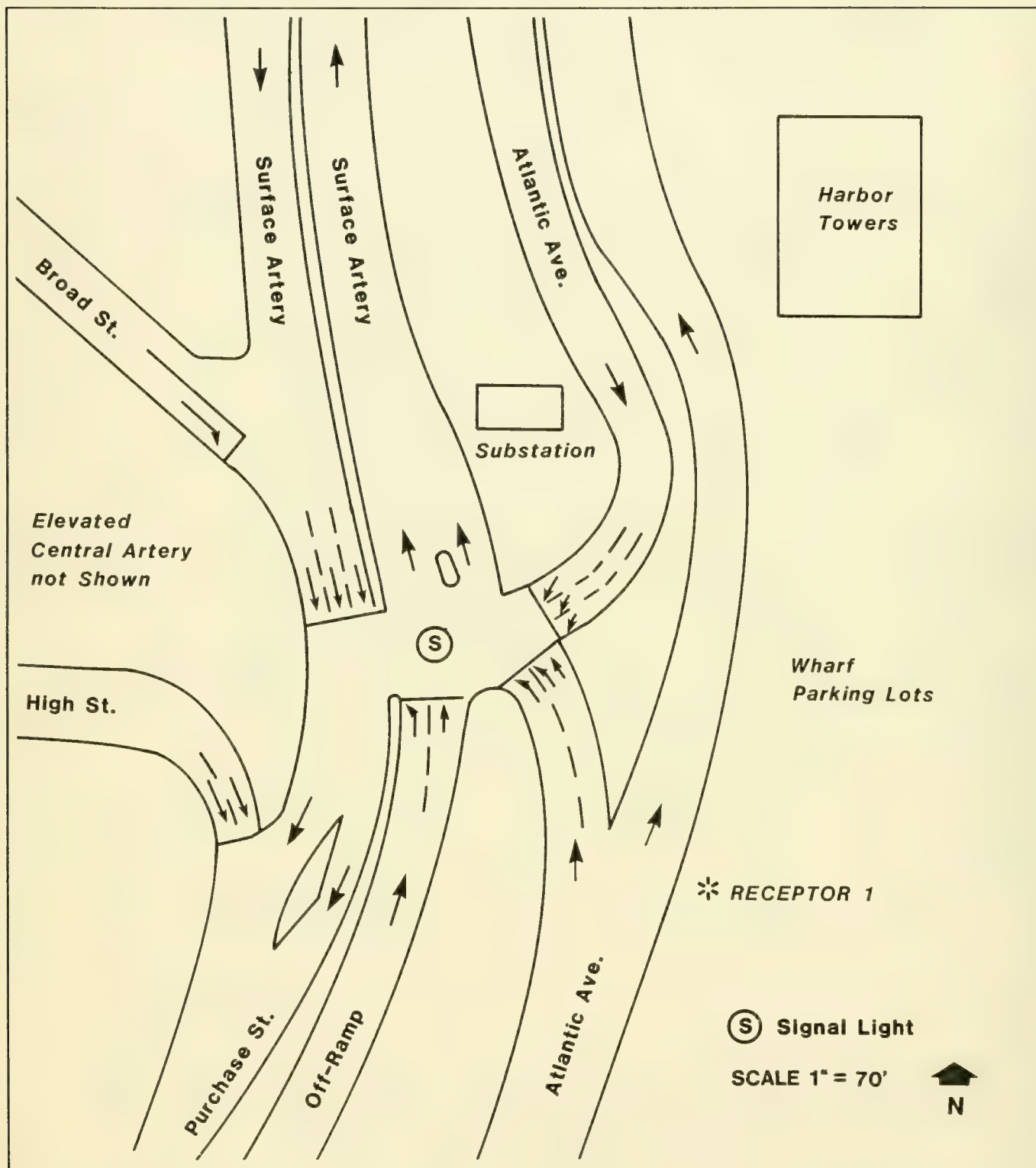
Figure 5.3.1 Receptor Location No. 1
Atlantic Avenue/Surface Artery/High Street Case 1



International
Place
at Fort Hill

HMM Associates
Concord, MA

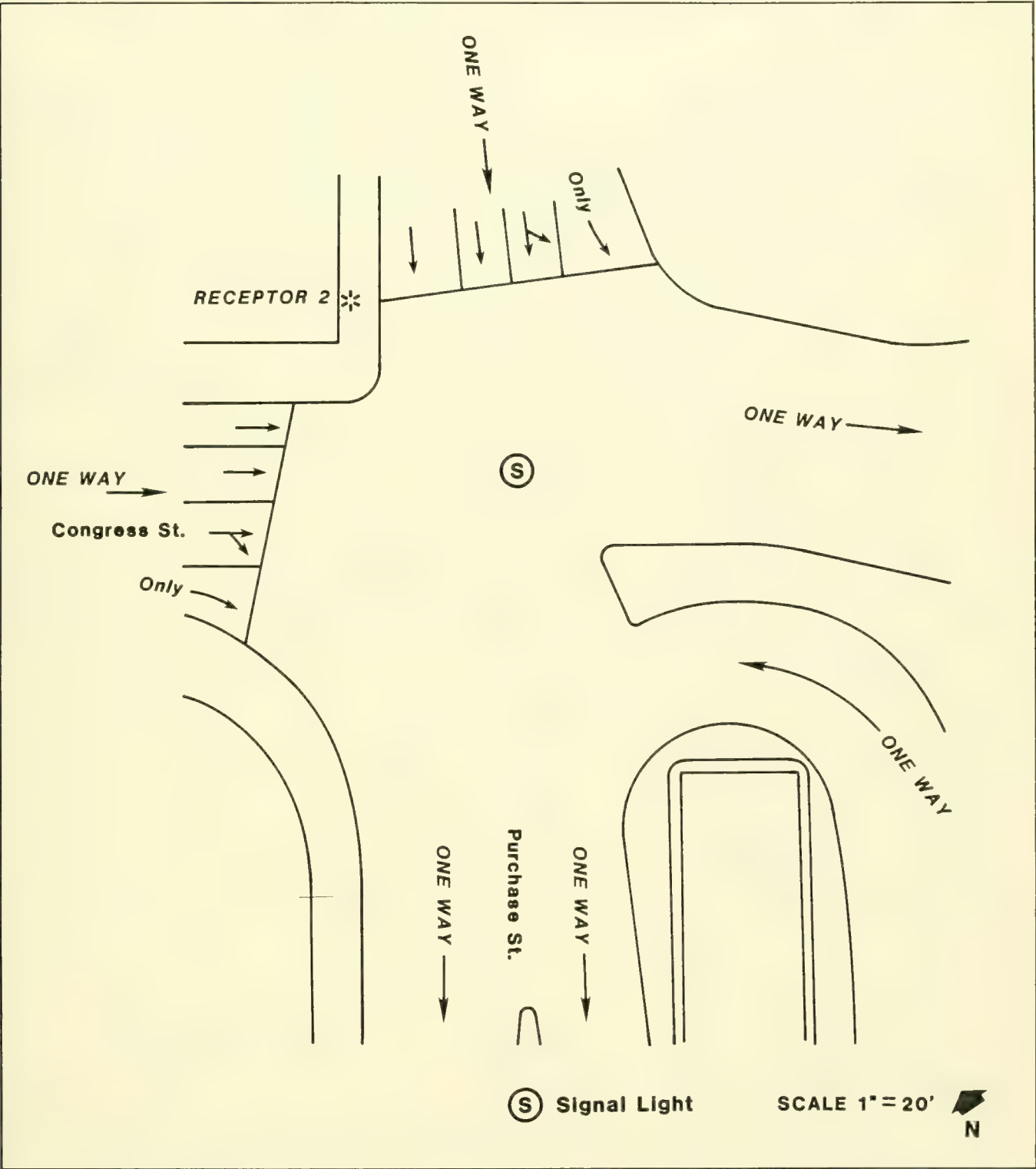
Figure 5.3.2 Receptor Location No. 1
Atlantic Avenue/Surface Artery/High Street Case 2 and 3



International
Place
at Fort Hill

HMM Associates
Concord, MA

Figure 5.3.3 Receptor Location No. 2 Purchase Street/Congress Street



International
Place
at Fort Hill

HMM Associates
Concord, MA

Figure 5.3.4 Receptor Location No. 3
International Place Access Drive/Purchase Street

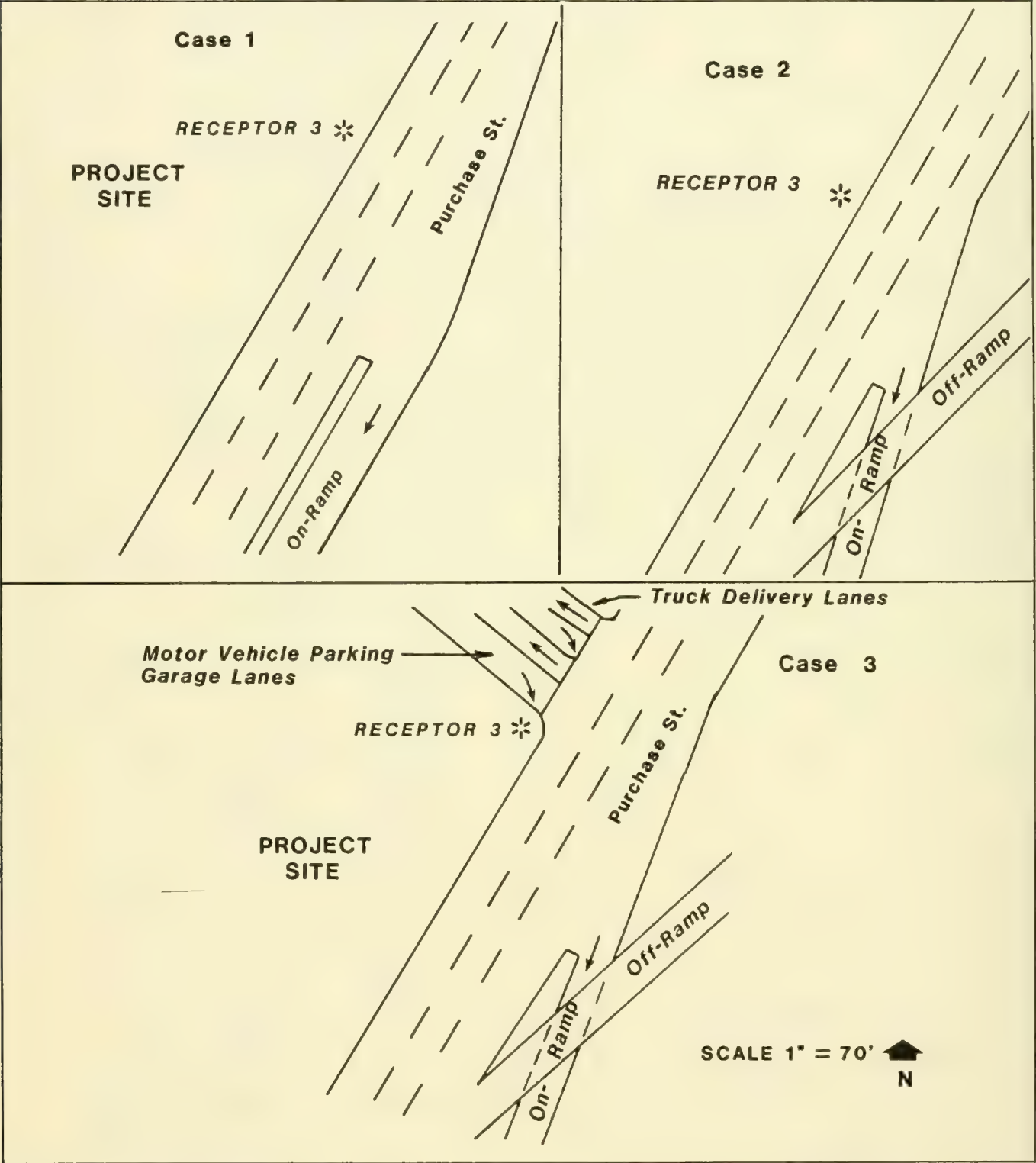
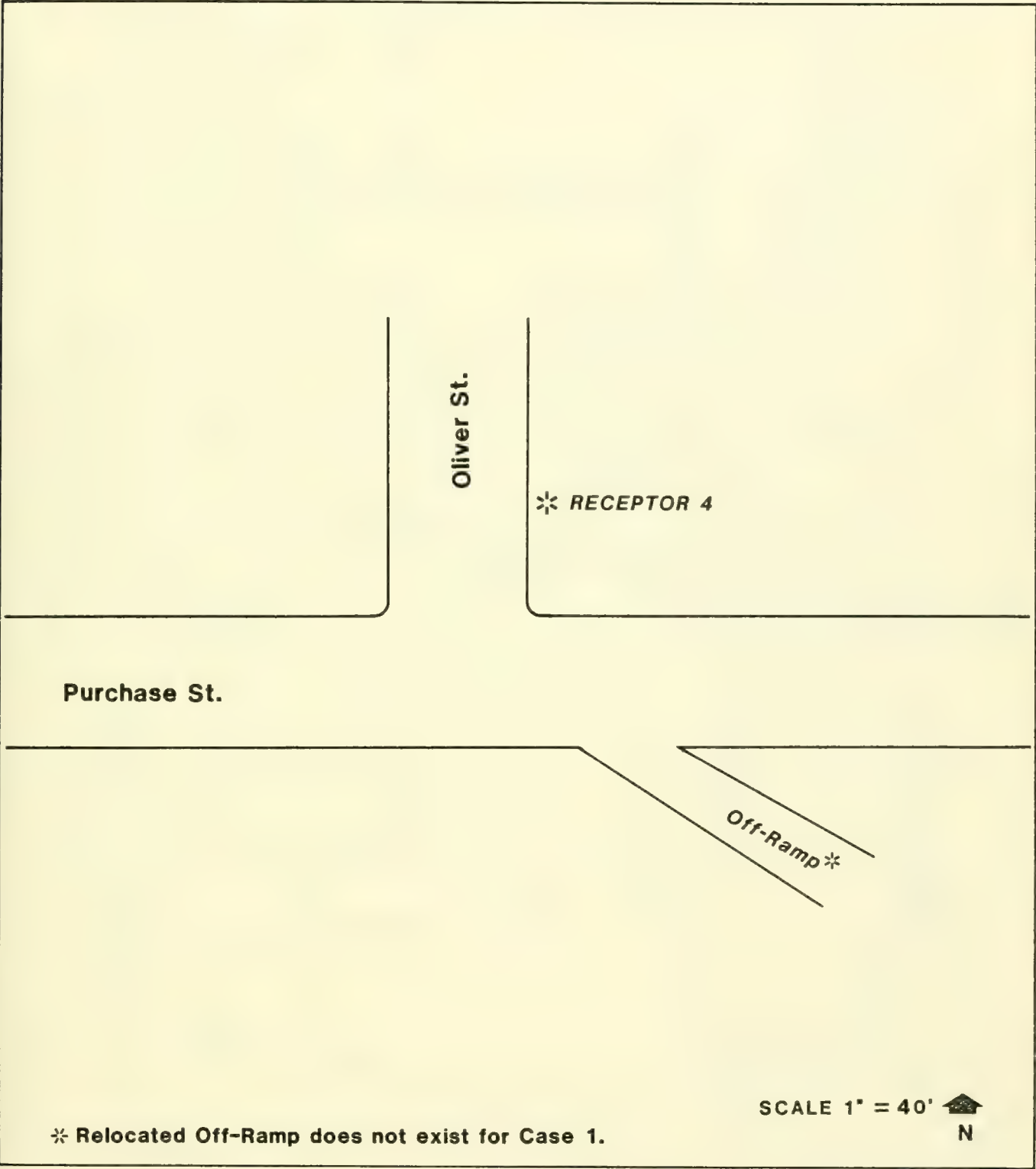


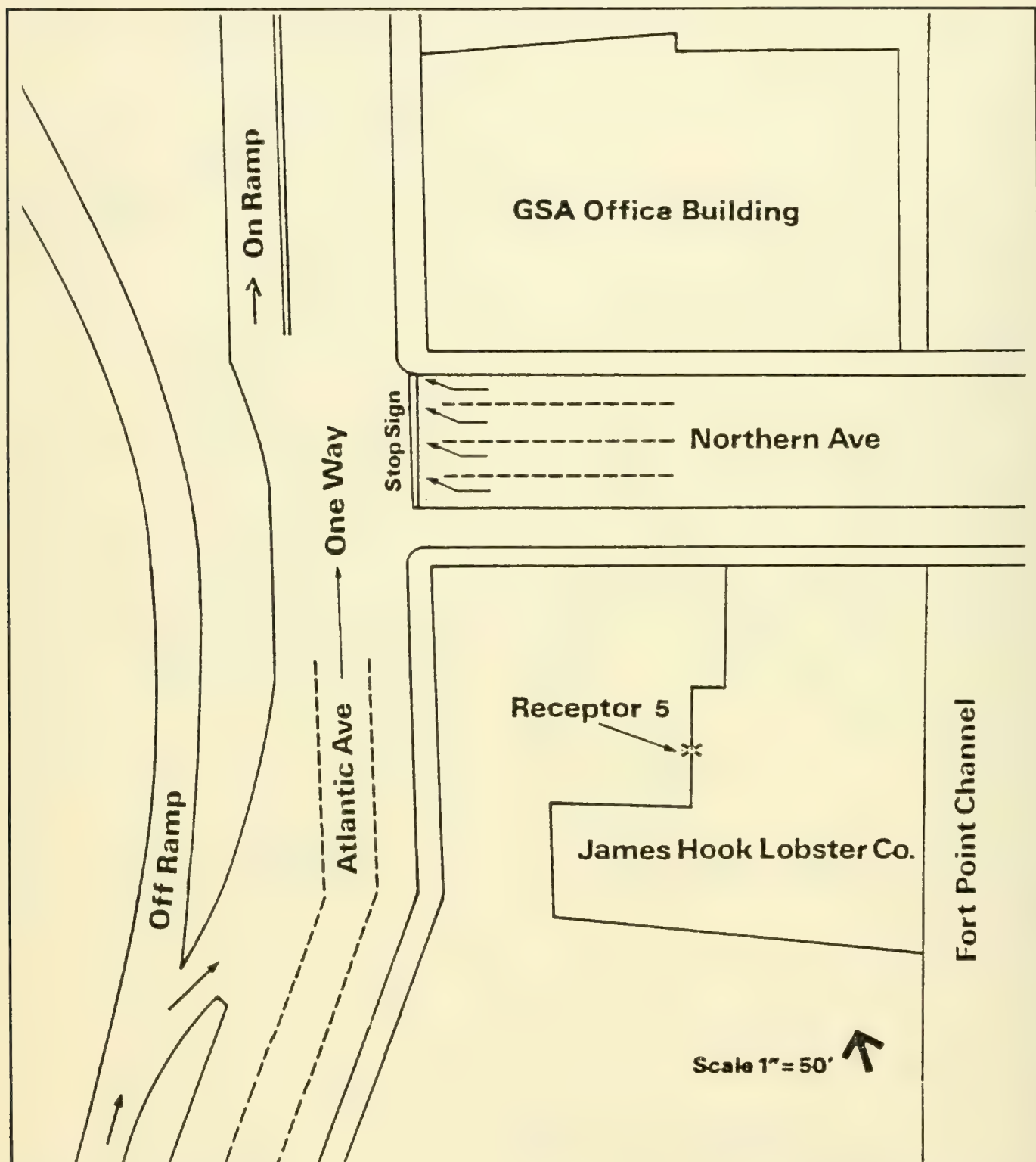
Figure 5.3.5 Receptor Location No. 4
Purchase Street/Oliver Street



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Concord, MA

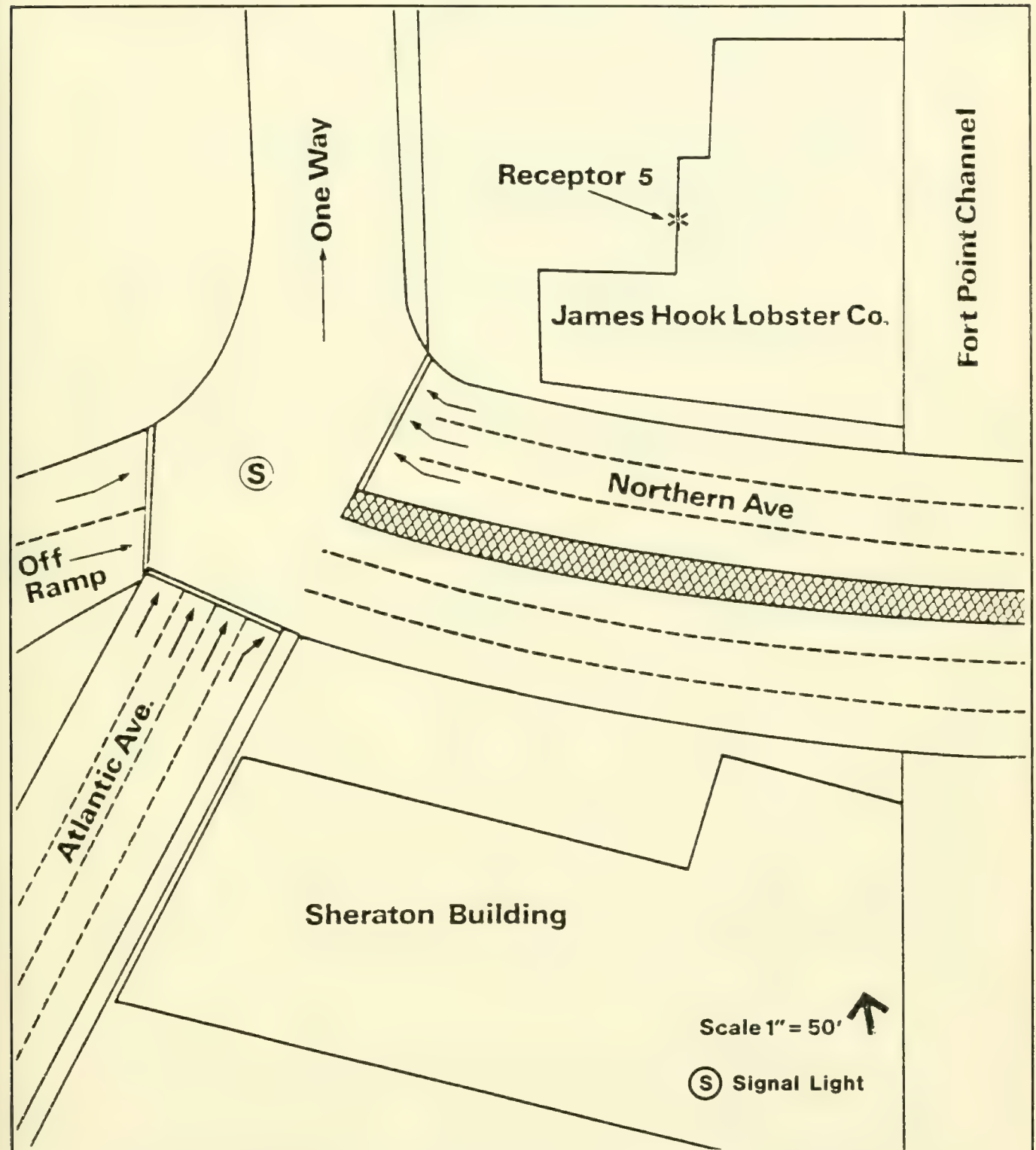
Figure 5.3.6 Receptor Location No. 5
Atlantic Avenue/Northern Avenue Case 1



International
Place
at Fort Hill

HMM Associates
Concord, MA

Figure 5.3.7 Receptor Location No. 5
Atlantic Avenue/Northern Avenue Cases 2 and 3



2. At the northwest corner of Purchase and Congress Streets (even with the stop line along Purchase Street),
3. On the south side of the parking garage access drive and west side of Purchase Street,
4. At the northwest corner of the Purchase Street and Oliver Street intersection, adjacent to the project's south tower, and
5. At the entrance to James Hook Lobster Co. adjacent to the Northern and Atlantic Avenue intersection (same as the Rowes Wharf EIR).

Figures 5.1 through 5.7 present source-receptor geometry, roughly to scale, at each intersection analyzed for CO concentrations. A stop sign control's Oliver Street at the intersection with Purchase Street. In addition, the International Place parking garage driveway was modeled as stop sign controlled. Estimation of cross street capacity at these intersections assumed a 4.5 second critical gap, based on Federal Highway Administration data*. A stop sign also controls Northern Avenue at the intersection with Atlantic Avenue under the existing case. Estimation of cross-street capacity for this case assumed a 3.5 second critical gap, consistent with the data and assumptions used for this intersection in the Commonwealth Pier EIR.** The other intersections are signalized.

* Behnam, J., "Gap Acceptance as a Criterion for Left Turn Phasing", Traffic Engineering, pp. 40-42, June 1972.

** Skidmore, Owings & Merrill, Final Environmental Impact Report, Commonwealth Pier Five Redevelopment, EOE #4133, Boston, MA, September 1982, p.102.

Signal phasing is noted on the Worksheets in the AQ Appendix B.

Maximum 1-hour and 8-hour CO concentrations from roadways were predicted at sensitive receptors using the EPA Indirect Source Guideline technique. The results of this analysis are presented in Table 5.3.3. Worksheets from the intersection analysis are included in the AQ Appendix B.

TABLE 5.3.3

PREDICTED MAXIMUM CO CONCENTRATIONS (PPM)
FROM INTERSECTIONS

Receptor	Existing		No-Build		Build	
	Case 1		Case 2		Case 3	
	1-Hr	8-Hr	1-Hr	8-Hr	1-Hr	8-Hr
1	23.5	5.4	18.9	3.7	19.8	3.8
2	29.8	6.7	20.5	4.9	22.0	5.2
3	15.1	3.7	12.8	3.4	21.7	3.5
4	8.3	2.1	8.2	2.2	8.8	2.2
5	11.9	2.5	15.6	3.4	16.2	3.5

The results of the intersection analysis, as summarized in Table 5.3.3, demonstrates that the highest total CO concentrations from roadway emissions occur at Receptor 2 (intersection of Purchase and Congress Streets). CO contributions from roadway emissions associated with additional project-generated traffic were found to be greatest at Receptor 3 for the 1-hour case. This is a result of additional queuing and idling of vehicles exiting the project parking garage onto Purchase Street. At all other locations studied, net increases in CO levels, attributed to the project, are small. None of the predic-

ted CO concentrations from roadways alone exceed the applicable air quality standards.

Parking Facility Analysis

A separate analysis was performed to determine impacts of the existing on-site parking lot and the project's 827 space five-level underground parking garage. The parking facility analysis predicted maximum 1-hour and 8-hour CO concentrations, for the three cases described above, using the EPA Indirect Source Guidelines and Halitsky's gas diffusion equations. Concentrations were calculated at Receptor 3 (for all cases) as it is located almost directly below the exhaust vent and Receptor 2 for the 1990 Build Case. In conjunction with the worst case wind directions and Class D stability (utilized in the intersection analysis), these are the only cases for which receptors are either downwind of the parking lot or where the horizontal plume spread is enough to impact a receptor. For similar reasons (i.e., upwind receptors or limited plume spread under worst case conditions) the Fort Hill Garage was not studied under the existing and 1990 No-Build cases. This situation represents the most conservative condition when comparing project-related impacts to the no-build condition during the design year.

For the build case, the proposed underground garage will be serviced by a forced-air ventilation system. For Phase I of the project, the exhaust vent will be a 12-foot high by 21-foot wide opening in the wall of the machine room located in the 27 story rectangular building element along Purchase Street. The vent faces east on Purchase Street. The base of the opening will be located 34 feet above grade, and the right-hand edge of the vent will be aligned with the northeast corner of this building. Total flow from the two garage fans of Phase I will be 175,000

cfm. For Phase II, the ventilation system design is only in preliminary stages. However, this system is expected to have similar characteristics to that of the Phase I design. The main exception will be that emissions from the Phase II section of the garage will be vented above the enclosed three story courtyard. Since this design has currently not been completed, it was assumed in the parking garage analysis that all garage emissions were emitted from the Phase I vent location. This assumption is the most conservative since the Phase I exhaust location is closest to the receptor locations examined. The ventilation systems air intakes will be located along Purchase, Oliver, and High Streets well away of any garage exhaust vents.

Under the existing and 1990 no-build cases, two surface lots totaling 167 spaces are located on the project site. These will no longer exist under the build case. Maximum CO concentrations from these lots were determined using the EPA Indirect Source Guidelines for area sources. Worksheets of supporting calculations are included in AQ Appendix C.

For the full build underground parking garage emissions were estimated using Worksheet 3 (see AQ Appendix C) of the EPA Indirect Source Guidelines. The ventilation system will emit 9.89 g/s of CO for the peak 1-hour period, and 1.50 g/s of CO (average hourly value) for the peak 8-hour period at the Purchase Street location. These emissions are based on both parking vehicles and trucks utilizing the underground loading area.

The concentration of CO in the ventilation system exhaust was determined by the following formula:

$$X = 870 (Q + (X_b)(F))/F$$

where: X = CO concentration in the ventilation exhaust (ppm)

Q = CO emission rate for the vent system (g/s)

X_b = Background concentration of CO in the makeup air assumed equal to the 1990 background concentrations used in this analysis (g/m³)

F = Volumetric flow rate (m³/s)

The 1990 background concentrations of 3.6 ppm and 2.1 ppm (as calculated in the previous subsection) are equivalent to 4.14×10^{-3} g/m³ and 2.41×10^{-3} g/m³, respectively. Concentrations in the exhaust air will be:

1-hour X = 107.8 ppm

8-hour X = 17.9 ppm

For a near-field* receptors such as Receptors 2 and 3, ambient concentrations were scaled from the ventilation air concentrations using Halitsky's empirical model for gas diffusion near buildings. This model states that the ambient concentration X_a equals:

$$X_a = X/D$$

where D is a dilution factor defined as follows:

$$D = 2.22 M \left[3.16 + \frac{0.1(S)}{(Ae)^{1/2}} \right]^2 \left[\frac{V}{V_e} \right]$$

* near-field refers to the downwind cavity and turbulent wake region directly adjacent to the exhaust vent building. This is generated as the air stream flows around the building.

The terms are defined as follows:

- M = building configuration factor, equal to 4.0 for ground-level receptors in the cavity of the exhaust plume
- S = shortest arc distance from source to receptor (m).
- Ae = area of the exhaust opening is 23.4m².
- V = ambient wind velocity
= 1.0 m/s (1-hour)
= 1.6 m/s (8-hour)
- Ve = source exit velocity
= 3.53 m/s

Table 5.3.4 summarizes the model input parameters for Receptors 2 and 3. These values represent actual physical characteristics of the ventilation system as presented above, source-receptor geometry, and worst case wind conditions.

TABLE 5.3.4
MODEL INPUT PARAMETERS FOR CALCULATION OF THE
IP PARKING GARAGE VENTILATION IMPACTS

<u>Receptor</u>	<u>M</u>	<u>S(m)</u>	<u>Ae(m²)</u>	<u>V (m/s)</u>	<u>Ve(m/s)</u>	<u>D</u>
2	4.0	243.8	23.4	1.0/1.6*	3.53	169.1/270.6*
3	4.0	10.4	23.4	1.0/1.6*	3.53	28.7/45.9*

* 1-Hour/8-Hour

Impacts of the parking lot and project garage at Receptors 2 and 3 are presented in Table 5.3.5.

TABLE 5.3.5
WORST CASE CO CONCENTRATIONS FROM THE EXISTING
PARKING LOT AND INTERNATIONAL PLACE PARKING GARAGE

<u>Receptor</u>	<u>Case 1*</u>		<u>Case 2*</u>		<u>Case 3**</u>	
	<u>1-Hr</u>	<u>8-Hr</u>	<u>1-Hr</u>	<u>8-Hr</u>	<u>1-Hr</u>	<u>8-Hr</u>
2	0.0	0.0	0.0	0.0	0.6	0.1
3	3.5	0.4	2.3	0.3	3.8	0.4

* Existing Parking Lot

** International Place Parking Garage

The results indicate that CO contributions from the parking facilities, in general, are small. Projected related increases during the design year are also small as levels only increase 1.5 ppm and 0.1 ppm for the 1-hour and 8-hour periods, respectively.

Plume Trapping

The effect of plume trapping was examined as concerns were raised over the potential for increased pollutant levels below the elevated central artery in the vicinity of the project. Plume trapping occurs when the mixing of pollutants is limited in the vertical direction as a result of either structural or meteorological conditions conducive to this condition. The potential effect of plume trapping below the central artery was examined using CO monitoring data from the Air Quality Analysis of the North Station Urban Renewal Project*. In this study, air quality monitoring data for CO were collected at two sites near 133 Causeway Street. One monitoring site had a sensor

* Chang, K.M., et al., Air Quality and Noise Impact Analyses of the North Station Urban Renewal Project, Bolt, Beranek, and Newman Inc., Report No. 4477, June 1982 (Revised January 1983 and September 1983).

located below the elevated MBTA tracks at a height of 3 meters above Causeway Street. The second site had a sensor situated 1.5 meters above the elevated tracks. A schematic of the monitoring program is presented in Figure 5.3.8. This program was designed to investigate entrapment of CO below the elevated tracks. The results of the North Station study are presented in Table 5.3.6. This data shows that the maximum concentrations monitored below the elevated section (where pollutant entrapment is expected) were not much higher than the levels monitored above the elevated tracks (where entrapment does not occur). The results indicate that maximum 1-hour and 8-hour CO levels monitored below the elevated section were 25% and 27%, respectively, higher than those monitored above the tracks. Higher levels measured below the elevated tracks in comparison to levels above the elevated tracks can be a result of two effects: (1) the monitoring site below the tracks is closer to ground level and thus closer to the roadway source, and (2) the effect of pollutant trapping (limited mixing in the vertical direction) underneath the elevated section.

In order to determine the expected increase in pollutant levels below the elevated track section as a result of entrapment, the effect of the height difference alone between the two monitoring sites was examined. This was done using the EPA Indirect Source Guidelines. The "street canyon" equations were utilized as results indicate a vortex circulation of the wind within the Causeway Street canyon occurs. For the lee side of the canyon increases in CO levels can be described as follows:

$$X = \frac{1}{(u + 0.5)(x + z)^{1/2}} + L_o$$

Figure 5.3.8 Schematic of North Station CO Monitoring Program at Causeway Street

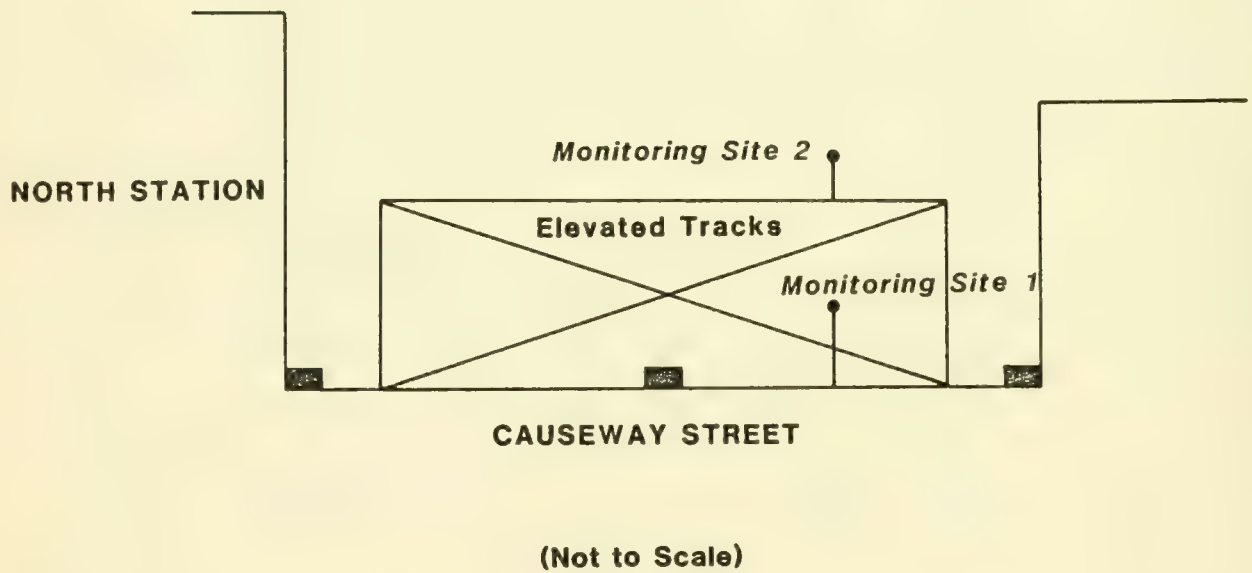


TABLE 5.3.6

MAXIMUM CO LEVELS (PPM) MEASURED AT THE
STREET LEVEL AND ELEVATED SENSORS
AT 133 CAUSEWAY STREET

	<u>1-Hour</u>	<u>8-Hour</u>
Street Level	26.4	13.8
Elevated	21.1	10.0

where: u = rooftop wind speed (m/s)

x = horizontal difference from
 stream center to receptor (m)

z = vertical distance from ground
 level (m)

L_o = approximate vehicle length
 (20m)

Using the values of $U = 1$ m/s, $x = 2$ m, $z_1 = 3.0$ m, and $z_2 = 11.5$ m, the ratio of lower to upper monitoring sites should be 2.64 to 1 (or 165% higher) based only on sensor height differences.

For the windward side the following equation applies:

$$X \propto H_b - Z$$

where: H_b = average building height

Using $H_b = 20$ m, the ratio of lower to upper probes should be 2.00 (or 100% higher) based only on the sensor height difference.

The above indicates that based on theoretical calculations the 25% and 27% (1-hour and 8-hour, respectively) higher pollutant levels monitored below the elevated tracks in the North Station study could be totally a result of the height difference (with respect to the roadway CO source). In this case no perceptible effect of plume entrapment is demonstrated. However, opposite to this is the worst case situation where the 25% and 27%

increase is attributed entirely to plume entrapment. This can occur under the situation where mixing within the Causeway Street canyon is vigorous enough to cause uniform CO levels. In this case height differences would play no role in pollutant levels.

Using the latter case, since it represents the worst case situation, a conservative estimate of CO levels below the elevated central artery (at the Atlantic Avenue/Surface artery intersection) was made using the intersection and garage modeling results at Receptor 1. Receptor 1 was utilized as traffic data for this location reflects worst case conditions below the elevated Central Artery at the intersection of Atlantic Avenue and Surface Artery intersection. The effect at other receptors was not examined as the traffic modeled for these locations is away from the elevated Central Artery. The procedure for determining CO levels below the elevated section of the central artery was to increase CO levels calculated at Receptor 1 by 25% and 27% for the 1-hour and 8-hour periods, respectively, in accordance with the results of the North Station monitoring program. These results are presented in the following subsection.

Cumulative Results of the Air Quality Analysis

The air quality analysis predicted maximum 1-hour and 8-hour CO concentrations at sensitive receptors. The cumulative results of the air quality analysis, including impacts from intersection traffic, parking facilities and background are presented in Table 5.3.7. Predicted levels of CO at Receptor 1 (which is away from the elevated Central Artery) assume no effect of plume entrapment. However, a theoretical point (Receptor 1A) was defined below the Central Artery (at the Atlantic Avenue/Surface Artery intersection) having CO levels similar to Receptor

TABLE 5.3.7
PREDICTED MAXIMUM CO CONCENTRATIONS
PLUS BACKGROUND (PPM)

Receptor	Existing		No-Build		Build		NAAQS	
	Case 1		Case 2		Case 3			
	1-Hr	8-Hr	1-Hr	8-Hr	1-Hr	8-Hr	1-Hr	8-Hr
1*	28.5	8.4	22.5	5.8	23.4	5.9	35	9
1A**	35.6	10.7	28.1	7.4	29.4	7.5	35	9
2	34.8	9.7	24.1	7.0	26.2	7.4	35	9
3	23.6	7.1	18.7	5.8	29.1	6.0	35	9
4	13.3	5.1	11.8	4.3	12.4	4.3	35	9
5	16.9	5.5	19.2	5.5	19.8	5.6	35	9

* Worst case CO levels at the intersection of Atlantic Avenue and the Surface Artery away from the elevated Central Artery.

** Worst Case CO levels at the intersection of Atlantic Avenue and the Surface Artery below the elevated Central Artery.

1 except that the worst case effect of plume trapping was assumed as described in the above subsection. These results do not characterize typical air pollution levels in the project area. Rather, they represent the highest concentrations that could exist during the joint occurrence of worst case meteorology and peak traffic. Predicted levels at Receptors 1 (no plume trapping) and 5 differ from the previous results of the Rows Wharf EIR as traffic data and vehicle age distributions have been updated (see the Transportation Analysis and AQ Appendix A).

Modeling results of the existing case shows the potential for three violations of the National Ambient Air Quality Standards (NAAQS). A CO concentration of 35.6 ppm (0.6 ppm above the standard) was predicted below the elevated section of the Central Artery. For the 8-hour period, levels of 9.7 ppm at Receptor 2 (Purchase Street/Congress Street intersection) and 10.7 ppm (below the elevated Central Artery) were calculated. These represent levels of 0.7 ppm and 1.7 ppm above the 8-hour NAAQS for CO.

Under the 1990 No-Build case no violations of the NAAQS for CO were predicted. The highest 1 and 8-hour concentrations predicted were 28.1 ppm and 7.4 ppm, respectively, both below the elevated central artery. The decrease in CO levels from Case 1 (Existing) to Case 2 (1990 No-Build), even when traffic data increases, is a direct result of federal regulations requiring new car manufacturers to reduce motor vehicle emission on a yearly bases.

Under the 1990 Build case no violation of the NAAQS for CO were predicted. The maximum 1-hour and 8-hour CO concentrations were again found to be below the elevated Central Artery where levels of 29.4 ppm and 7.5 ppm, respectively, were calculated. For the design year the maximum net increase in CO was predicted at Receptor 3 (intersection of Purchase Street and project paking garage drive) where levels increased 56% for the peak 1-hour period. In all other cases project-related traffic only induced relatively small net increases.

The general conclusion is that the results indicate a potential violation of the 8-hour NAAQS for CO under existing conditions, however, no violations are predicted during the design year. Therefore it is evident that International Place will not interfere with the attainment

and maintenance of the NAAQS for CO. Also, no changes to the Massachusetts State Implementation Plan (SIP) are expected as results indicate no exceedences of the air quality standards after 1987 due to the construction of this project.

Mitigation Measures

The Commonwealth's I&M program started on April 1, 1983 and has been assumed in the calculation of motor vehicle emission rates. This program, which results in the overall reduction of yearly motor vehicle emissions, was established to ensure compliance with the NAAQS as outlined in the Massachusetts State Implementation Plan. The attainment and maintenance of the NAAQS for CO in the future is dependent on the continued enforcement of this program. Other traffic-related mitigation measure to reduce vehicle conflicts and delays could similarly improve future air quality. Such traffic-related measures include van and car pooling which reduce traffic volumes. In addition, signal timing changes which enhance traffic movement, roadway geometry changes which increase roadway capacities, and removal of on-street parking which also increases roadway capacities produce positive effects in reducing vehicle emission of pollutants. None of these actions appears necessary as a mitigation measure for air quality, since no violations of the applicable standards are predicted. However, as part of this project the proponent is supporting efforts to increase measures of van and car pooling to improve traffic conditions in the project area.

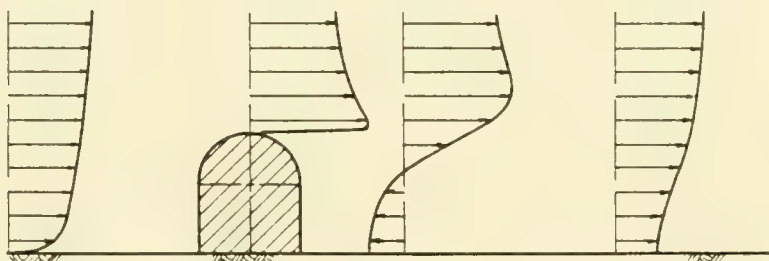
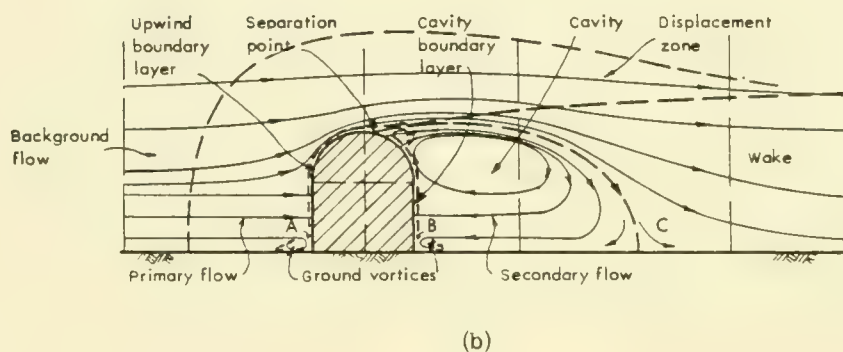
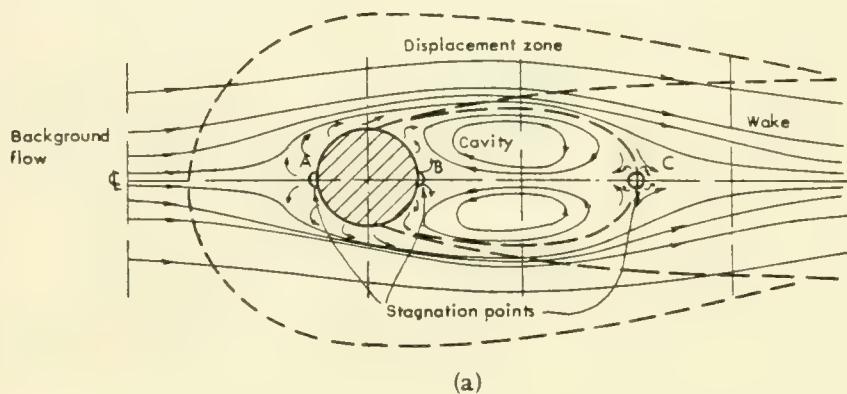
5.3.3 Effect of Air Flow Modification on Pollutant Dispersion

Under the Build Case it is expected that the International Place Project will modify the local wind field and therefore alter the transport and diffusion of air pollutants. Wind tunnel and field experiments demonstrate the potential for a stagnation point about two-thirds the way up a high-rise building on the upwind facade.* Below this point winds are deflected to the ground as upper level winds against the upper face of a high-rise building create a downward pressure gradient. Also, turbulence is generated on the side and roof, and downwind of a cavity of recirculating air on the lee side of the building. The lee side turbulence becomes more evident as the obstacle becomes less rounded, taller or warmer relative to the ambient air. In general, these effects will enhance dispersion as upper level winds are deflected to the ground and pass around the building elements. Induced turbulence will also increase the rate of dispersion on the lee side of a high-rise building. Immediately adjacent to the lee side of the building, in the cavity of recirculating air, pollutants are well mixed such that levels are generally more uniform in this region. Figure 5.3.9 presents a schematic of air flow about a rounded building similar to the cylindrical high-rise towers of International Place.

Many of these physical characteristics (described above) were found in the International Place flow visual-

* Hanna, Steven R., Gary A. Briggs, Rayford P. Hosker, Jr., Handbook on Atmospheric Diffusion, Technical Information Center, U.S. Dept. of Energy, 1982, pp. 19.

Figure 5.3.9 Flow Around a Rounded Building



Slade, David H. (editor), Meteorology and Atomic Energy 1968, USAEC, July, 1968

International
Place
at Fort Hill

HMM Associates
Concord, MA

ization study* which demonstrated that the overall effect of the International Place complex was to enhance mixing in the vertical direction as upper level winds were deflected down to the surface on the windward side and surface air was pulled to upper levels on the lee side of the proposed buildings. The study showed that polluted surface air was being mixed into the upper levels of the atmosphere where higher velocity winds could disperse air pollutants. The study also demonstrated some decreases in wind speeds at a few distances downwind of the complex which might decrease slightly the dispersal of pollutants.* However, the overall mixing action of the project is expected to outweigh small decreases in wind speeds downwind.

5.3.4 Construction Related Impacts

During the 64-month construction period of Phases I (South Tower) and II (North Tower) of the International Place project, short-term adverse effects on air quality adjacent to the construction site and along major access routes may occur. Impacts associated with land clearing, blasting, ground excavation, cut and fill operations, and construction activities may generate fugitive dust, which results in localized increase in Total Suspended Particulate (TSP) levels.

The major dust emitting activities will occur during the construction activities involving excavation and foundation work (10 months). Principal on-site sources of particulate matter include the excavation process and exposed aggregate storage piles. For each source type,

* Peterka, J.A. and J.E. Cermak, Wind Tunnel Study of International Place, Boston, Part 1: Pedestrian Flow Visualization, (CSU Project 2-95820, March, 1984).

emissions will depend on such factors as the properties of emitting surfaces (e.g., soil silt content, moisture content and volume of spoils), meteorological variables and the construction practices employed. It is anticipated that emissions from aggregate storage piles will be minimal for International Place as the project site is small thus limiting its storage capacity.

Exposed piles of earth removed in the process of excavation, or aggregate piles of construction material dumped at the site, are potential dust emitters during mechanical disturbance and transfer operations, as well as during high winds. In either case, the bulk of the dust is emitted shortly after the initial loading of a freshly processed aggregate because it is during this period that the fine particles are most easily dislodged. Any subsequent rainfall moistens the interior of the pile and the moisture is released very slowly. Thus, the emissions from storage piles depend primarily on the regional precipitation/evaporation (PE) index. The PE index is a measure of the precipitation to evaporation ratio and in the contiguous United States ranges from an approximate low of 10 in the arid southwest to approximately 170 in the upper northeast. In the Boston area, the PE index is 132, well above the average for the U.S. as a whole.

The EPA document AP-42* provides an emission factor of 1.2 tons of suspended dust emissions per acre of construction per month for heavy construction operations. This value is based on field measurements of emissions from apartment and shopping center construction projects. It applies to operations of medium activity, moderate silt content (approximately 30 percent), and a PE index of 50.

* EPA, Compilation of Air Pollution Emission Factors, AP-42, RTP, NC, May, 1983, Section 11.2.4.

Indications are that heavy construction operations are proportional to silt content of the soil, and inversely proportional to the square of the PE Index. A value of 0.17 tons per acre of construction per month was developed for Boston utilizing a PE index of 132 instead of 50. A silt content of 30% was assumed to be applicable for this case as borings indicated soil beneath the site consisted of a brown coarse to fine sand with varying amounts of silt, clay, and gravel.

Applying this factor to the 2.6-acre International Place project provides an estimate of potential for 4.4 tons (over 10 months) of fugitive dust generated from construction activities.

(2.6 acres x 0.17 tons per acre per month x 10 months).

Mitigation Measures

The construction contract will provide for a number of strictly enforced measures to be utilized by contractors to reduce predicted fugitive dust emissions and minimize impacts. These include:

- o The use of wetting agents on areas of exposed soil on a scheduled basis.
- o Use of covered trucks.
- o Storage of very few spoils on the construction site.
- o Monitoring of actual construction practices to ensure that unnecessary transfers and mechanical disturbances of loose materials are minimized.
- o Locating aggregate storage piles away from areas having the greatest pedestrian activity.

5.3.5 Handling and Removal of Asbestos Material

The Massachusetts DEQE will be notified 20 days prior to commencement of onsite demolition in compliance with 310 CMR 7.15. Written notice will include the following information: 1) the name of the owner or operator, 2) address of the owner or operator, 3) address or location of building, 4) scheduled starting and completion dates of the demolition, and 5) the measured or estimated amount of asbestos material. In addition, the US EPA will be notified 20 days prior to any demolition involving asbestos.

A preliminary inspection of existing structures has found that the amount of asbestos material onsite appears to be small. Currently, the only known asbestos is the insulation on steam pipes feeding into basements of onsite buildings and one boiler insulating jacket. No structural asbestos insulation has been located as of the present time. The existing 660 space City of Boston parking garage (whose construction is reinforced concrete) has not been thoroughly examined, but amounts of asbestos in this building are expected to be small. The only potential location of this material is on incoming steamlines located in the basement area.

The methodology for the handling and removal of asbestos material and precautions taken is expected to be as follows:

1. The area containing the asbestos material will be sealed off.
2. All workers involved in the removal of asbestos material will wear protective clothing and respiratory masks for protection. In addition they will change in an isolated and separate area.

3. Wetting agents will be utilized to wet down asbestos material.
4. The asbestos will be dismantled and placed in double lined plastic bags.
5. Each bag will be labeled to provide information on its contents and specify destination. (The disposal site has not yet been determined).

In addition, any other precautionary measures and procedures required by the Massachusetts DEQE will be followed upon DEQE's inspection of the project site.

AQ APPENDIX A

CALCULATION OF MOTOR VEHICLE

EMISSION RATES FOR CARBON MONOXIDE

Motor vehicle emission rates for carbon monoxide (CO) used in this analysis were generated by the EPA MOBILE2 computer program*. As the emission conditions relevant to this study are not covered by the correction factors given in the Guideline document**, this approach resulted in more accurate characterization of emissions. The use of these data required a slight change in the procedure for Worksheet 2, as follows. First, the free-flow emission rate entered on line 5 was taken from tables in this Appendix and thus was already corrected. This eliminated the need to multiply by C_T in calculating lines 17b and 18. Second, the idle mode emission rate for the standard conditions used in the Guideline was updated to 0.254 g/s, the value now given by MOBILE2. Third, the idle mode correction factors used to calculate line 17a were taken from Table A.7 in this Appendix. These factors were established by dividing idle mode emission rates for actual study area conditions by the idle mode emission rate for the standard conditions used in the Guideline (viz. year = 1977, temperature = 75°F, vehicle mix = 100% LDV, cold start = 0%, hot start = 0%). Emissions for a vehicle speed of 5 mph were used as idle mode rates in this analysis since MOBILE2 does not provide for calculation of idle emission rates using a cold/hot start vehicle mix. This substitution did not introduce any significant error into the calculations. One further change was introduced in Worksheet 2. At the request of

* EPA, User's Guide to MOBILE2: Mobile Source Emissions Model, EPA-460/3-81-006, Ann Arbor, MI, February, 1981.

** EPA, Guidelines for Air Quality Maintenance Planning and Analysis Volume 9 (Revised): Evaluating Indirect Sources, Second Printing, EPA-450/4-78-001, Research Triangle Park, NC, September, 1978.

DEQE, the vehicle spacing distance of 8 meters used to calculate the queue length in Line 8 was changed to 4.35 meters.

Roadway CO emission rates used in this study are based on the MOBILE2 default national motor vehicle mix (see Table A.1), an average December temperature of 33°F, and the most recent 1983 Massachusetts registration distribution for light duty vehicles, light duty trucks, and heavy duty trucks (see Table A.2). These CO emission rates are conservative estimates since they assume a medium and heavy-duty truck component of 10.5 percent (see Table A.1) while the actual truck component (at traffic monitoring locations) during peak hours is less.

The MOBILE2 default national cold/hot start mix (presented in Table A.3) was used for determining roadway emissions during the peak eight-hour period. A mix with a higher cold start percentage for the evening rush hour was used to represent the peak one-hour period (see Table A.4). For the existing and proposed parking facilities 100% cold starts was used for exiting vehicles and 100% hot stabilized for vehicles entering. Emission rates are based on peak one-hour and eight-hour travel speeds for vehicles approaching each intersection as estimated from field surveys. Table A.5 and Table A.6 present the composite CO emission rates for the peak one-hour and eight-hour periods, respectively. Table A.7 gives the idle mode correction factors used in the analysis. The complete MOBILE2 output is found at the end of the text for this section.

TABLE A.1
NATIONWIDE AVERAGE
MOTOR VEHICLE MIX BY TYPE*

<u>Vehicle Type</u>	<u>Percentage of VMT</u>	
	<u>1984</u>	<u>1990</u>
Light-Duty Gasoline Vehicles (LDGV)	77.6	71.3
Light-Duty Gasoline Trucks		
0-6000 lb GVW** (LDGT1)	8.1	7.4
Over 6000 lb GVW (LDGT2)	3.7	3.7
Heavy-Duty Gasoline Trucks (HDGV)	3.9	3.8
Light-Duty Diesel Vehicles (LDDV)	2.5	8.7
Light-Duty Diesel Trucks (LDDT)	0.3	1.1
Heavy-Duty Diesel Trucks (HDDT)	3.0	3.0
Motorcycles (MC)	<u>0.9</u>	<u>1.0</u>
Total Percent	100.0	100.0
Medium and Heavy-Duty Trucks (HDDT + HDGV + LDGT2)	10.6	10.5

* EPA, User's Guide to MOBILE2: Mobile Source Emissions Model, EPA-460/3-81-006, Ann Arbor, MI, February, 1981.

** Gross vehicle weight.

TABLE A.2
1983 MASSACHUSETTS VEHICLE
REGISTRATION DISTRIBUTION

Vehicle Age in Years	Percent of Total Vehicles		
	<u>LDGV, LDDV</u>	<u>LDGT, LDDT</u>	<u>HDT (Gas & Diesel)</u>
1	5.4	6.3	4.2
2	7.3	6.9	7.2
3	8.1	5.8	5.4
4	8.2	5.9	5.3
5	9.1	12.6	8.4
6	8.7	9.8	10.0
7	7.9	8.8	8.2
8	7.7	6.5	6.2
9	6.1	4.6	4.8
10	7.0	6.6	6.4
11	6.8	5.7	6.4
12	5.2	4.6	7.8
13	3.5	3.4	3.8
14	2.8	2.7	3.2
15	1.7	2.2	3.0
16	1.4	1.8	2.4
17	1.1	1.7	2.1
18	.8	1.6	1.9
19	.7	1.4	1.8
<u>20 +</u>	<u>.5</u>	<u>1.1</u>	<u>1.5</u>
Total	100.0	100.0	100.0

Source: Massachusetts Department
of Environmental Quality
Engineering

TABLE A.3
NATIONWIDE AVERAGE
COLD/HOT START MIX FOR MOTOR VEHICLE

Vehicles Cold	
Start Mode	20.6%
Vehicles Hot	
Start Mode	27.3%
Vehicles Hot	
Stabilized Mode	<u>52.1%</u>
Total	100.0%

TABLE A.4
RUSH HOUR COLD/HOT
START MIX FOR MOTOR VEHICLES

Vehicles Cold	
Start Mode	50.0%
Vehicles Hot	
Start Mode	10.0%
Vehicles Hot	
Stabilized Mode	<u>40.0%</u>
Total	100.0%

TABLE A.5

COMPOSITE CO EMISSION RATES
FOR THE PEAK ONE-HOUR PERIOD

<u>Approach Speed (mph)</u>	<u>CO Emission Rate (grams/mile)</u>		<u>CO Emission Rate (grams/meter)</u>	
	<u>1984</u>	<u>1990</u>	<u>1984</u>	<u>1990</u>
20	90.6	43.6	.0563	.0271
21	87.0	42.0	.0541	.0261
22	83.6	40.4	.0519	.0251
24	77.2	37.4	.0480	.0232
26	71.3	34.5	.0443	.0214
28	65.8	31.9	.0409	.0198

TABLE A.6

COMPOSITE CO EMISSION RATES
FOR THE PEAK EIGHT-HOUR PERIOD

<u>Approach Speed (mph)</u>	<u>CO Emission Rate (grams/mile)</u>		<u>CO Emission Rate (grams/meter)</u>	
	<u>1984</u>	<u>1990</u>	<u>1984</u>	<u>1990</u>
25	50.2	25.9	.0312	.0161
26	48.2	24.9	.0300	.0155
29	42.8	22.1	.0266	.0137
30	41.2	21.2	.0256	.0132
32	38.3	19.7	.0238	.0122
33	36.9	19.0	.0229	.0118
35	34.6	17.8	.0215	.0111

TABLE A.7
IDLE MODE CORRECTION FACTORS*
BY CALENDAR YEAR

	<u>1984</u>	<u>1990</u>
Peak 1-Hour	1.67	0.74
Peak 8-Hour	1.13	0.53

* Correction factor is composite emission factor at 5 mph (from MOBILE2) divided by 182.4 g/mile, the emission factor at 5 mph for the standard conditions used in the Guideline document, namely
year = 1977, temperature = 75°F,
vehicle mix = 100% LDV, cold starts = 0%,
hot starts = 0%.

INTERNATIONAL PLACE - 1983 VAD - I&M

* TOTAL HC EMISSION FACTORS INCLUDE EVAP HC EMISSION FACTORS

CAL. YEAR: 1984 REGION: 49-STATE LOWALT ALT: 500. FT.
 TAMB: 33.0(F) 20.6/ 27.3/ 20.6
 LDGV I/M PROGRAM STARTING IN 1984
 STRINGENCY LEVEL 15% MECH TRAINING: NO
 I/M PROGRAM BENEFITS APPLY ONLY TO MODEL YEARS 1969 THROUGH 2020
 ATTENTION: THE DEFAULT VALUE OF 50% FOR TECHNOLOGY 4
 I/M IDENTIFICATION RATE HAS BEEN LEFT UNCHANGED

VEH TYPE	LDGV	LDGT1	LDGT2	LDGT	HOGV	LDDV	LDDT	HDDV	MC	ALL VEH
VEH SPD	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
VMT MIX	0.776	0.081	0.037		0.039	0.025	0.003	0.030	0.010	

COMPOSITE EMISSION FACTORS (GM/MILE)
 EXHST CO 46.41 47.80 53.16 49.49 200.78 1.15 1.77 11.04 23.17 50.18

CAL. YEAR: 1984 REGION: 49-STATE LOWALT ALT: 500. FT.
 TAMB: 33.0(F) 20.6/ 27.3/ 20.6
 LDGV I/M PROGRAM STARTING IN 1984
 STRINGENCY LEVEL 15% MECH TRAINING: NO
 I/M PROGRAM BENEFITS APPLY ONLY TO MODEL YEARS 1969 THROUGH 2020
 ATTENTION: THE DEFAULT VALUE OF 50% FOR TECHNOLOGY 4
 I/M IDENTIFICATION RATE HAS BEEN LEFT UNCHANGED

VEH TYPE	LDGV	LDGT1	LDGT2	LDGT	HOGV	LDDV	LDDT	HDDV	MC	ALL VEH
VEH SPD	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0
VMT MIX	0.776	0.081	0.037		0.039	0.025	0.003	0.030	0.010	

COMPOSITE EMISSION FACTORS (GM/MILE)
 EXHST CO 44.60 45.96 51.07 47.57 192.54 1.10 1.70 10.59 22.23 48.21

CAL. YEAR: 1984 REGION: 49-STATE LOWALT ALT: 500 FT
 TAMB: 33.0(F) 20.6/ 27.3/ 20.6
 LDGV I/M PROGRAM STARTING IN 1984
 STRINGENCY LEVEL 15% MECH TRAINING: NO
 I/M PROGRAM BENEFITS APPLY ONLY TO MODEL YEARS 1969 THROUGH 2020
 ATTENTION: THE DEFAULT VALUE OF 50% FOR TECHNOLOGY 4
 I/M IDENTIFICATION RATE HAS BEEN LEFT UNCHANGED

VEH TYPE	LDGV	LDGT1	LDGT2	LDGT	HOGV	LDDV	LDDT	HDDV	MC	ALL VEH
VEH SPD	29.0	29.0	29.0	29.0	29.0	29.0	29.0	29.0	29.0	29.0
VMT MIX	0.776	0.081	0.037		0.039	0.025	0.003	0.030	0.010	

COMPOSITE EMISSION FACTORS (GM/MILE)
 EXHST CO 39.55 40.80 45.35 42.23 172.05 0.98 1.52 9.45 19.74 42.81

CAL. YEAR: 1984 REGION: 49-STATE LOWALT ALT: 500 FT
 TAMB: 33.0(F) 20.6/ 27.3/ 20.6
 LDGV I/M PROGRAM STARTING IN 1984
 STRINGENCY LEVEL 15% MECH TRAINING: NO
 I/M PROGRAM BENEFITS APPLY ONLY TO MODEL YEARS 1969 THROUGH 2020
 ATTENTION: THE DEFAULT VALUE OF 50% FOR TECHNOLOGY 4
 I/M IDENTIFICATION RATE HAS BEEN LEFT UNCHANGED

VEH TYPE	LDGV	LDGT1	LDGT2	LDGT	HOGV	LDDV	LDDT	HDDV	MC	ALL VEH
VEH SPD	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
VMT MIX	0.776	0.081	0.037		0.039	0.025	0.003	0.030	0.010	

VEH TYPE	LDGV	LDGT1	LDGT2	LDGT	HOGV	LDDV	LDDT	HDDV	MC	ALL VEH
VEH SPD	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
VMT MIX	0.776	0.081	0.037		0.039	0.025	0.003	0.030	0.010	

COMPOSITE EMISSION FACTORS (GM/MILE)
 EXHST CO 38.02 39.23 43.62 40.61 166.45 0.95 1.46 9.13 19.01 41.19

CAL. YEAR: 1984 REGION: 49-STATE LOWALT ALT: 500 FT
 TAMB: 33.0(F) 20.6/ 27.3/ 20.6
 LDGV I/M PROGRAM STARTING IN 1984
 STRINGENCY LEVEL 15% MECH TRAINING: NO
 I/M PROGRAM BENEFITS APPLY ONLY TO MODEL YEARS 1969 THROUGH 2020
 ATTENTION: THE DEFAULT VALUE OF 50% FOR TECHNOLOGY 4
 I/M IDENTIFICATION RATE HAS BEEN LEFT UNCHANGED

VEH TYPE	LDGV	LDGT1	LDGT2	LDGT	HOGV	LDDV	LDDT	HDDV	MC	ALL VEH
VEH SPD	32.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0
VMT MIX	0.776	0.081	0.037		0.039	0.025	0.003	0.030	0.010	

COMPOSITE EMISSION FACTORS (GM/MILE)
 EXHST CO 35.20 36.34 40.47 37.64 156.82 0.89 1.37 8.57 17.65 38.25

CAL. YEAR: 1984 REGION: 49-STATE LOWALT ALT: 500 FT
 TAMB: 33.0(F) 20.6/ 27.3/ 20.6
 LDGV I/M PROGRAM STARTING IN 1984
 STRINGENCY LEVEL 15% MECH TRAINING: NO
 I/M PROGRAM BENEFITS APPLY ONLY TO MODEL YEARS 1969 THROUGH 2020
 ATTENTION: THE DEFAULT VALUE OF 50% FOR TECHNOLOGY 4
 I/M IDENTIFICATION RATE HAS BEEN LEFT UNCHANGED

VEH TYPE	LDGV	LDGT1	LDGT2	LDGT	HOGV	LDDV	LDDT	HDDV	MC	ALL VEH
VEH SPD	33.0	33.0	33.0	33.0	33.0	33.0	33.0	33.0	33.0	33.0
VMT MIX	0.776	0.081	0.037		0.039	0.025	0.003	0.030	0.010	

COMPOSITE EMISSION FACTORS (GM/MILE)
 EXHST CO 33.93 35.05 39.04 36.30 152.72 0.86 1.34 8.33 17.03 36.94

CAL. YEAR: 1984 REGION: 49-STATE LOWALT ALT: 500 FT
 TAMB: 33.0(F) 20.6/ 27.3/ 20.6
 LDGV I/M PROGRAM STARTING IN 1984
 STRINGENCY LEVEL 15% MECH TRAINING: NO
 I/M PROGRAM BENEFITS APPLY ONLY TO MODEL YEARS 1969 THROUGH 2020
 ATTENTION: THE DEFAULT VALUE OF 50% FOR TECHNOLOGY 4
 I/M IDENTIFICATION RATE HAS BEEN LEFT UNCHANGED

VEH TYPE	LDGV	LDGT1	LDGT2	LDGT	HOGV	LDDV	LDDT	HDDV	MC	ALL VEH
VEH SPD	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0
VMT MIX	0.776	0.081	0.037		0.039	0.025	0.003	0.030	0.010	

COMPOSITE EMISSION FACTORS (GM/MILE)
 EXHST CO 31.69 32.76 36.50 33.93 145.79 0.82 1.27 7.91 15.91 34.63

* TOTAL HC EMISSION FACTORS INCLUDE EVAP HC EMISSION FACTORS

CAL YEAR: 1990 REGION: 49-STATE LOWALT ALT: 500 FT.
 TAMB: 33.0(F) 50.0/ 10.0/ 50.0
 LDGV I/M PROGRAM STARTING IN 1984
 STRINGENCY LEVEL 15% MECH TRAINING NO
 I/M PROGRAM BENEFITS APPLY ONLY TO MODEL YEARS 1975 THROUGH 2020
 ATTENTION: THE DEFAULT VALUE OF 50% FOR TECHNOLOGY 4
 I/M IDENTIFICATION RATE HAS BEEN LEFT UNCHANGED

VEH TYPE	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	ALL VEH
VEH SPD	20.0	20.0	20.0		20.0	20.0	20.0	20.0	20.0	
VEH MIX	0.713	0.074	0.037		0.038	0.087	0.011	0.030	0.010	

COMPOSITE EMISSION FACTORS (GM/MILE)
 EXHST CO 44 53 53 48 55 70 54 21 125 58 1.69 2 71 13 97 43 44 43 60

CAL YEAR: 1990 REGION: 49-STATE LOWALT ALT: 500 FT
 TAMB: 33.0(F) 50.0/ 10.0/ 50.0
 LDGV I/M PROGRAM STARTING IN 1984
 STRINGENCY LEVEL 15% MECH TRAINING NO
 I/M PROGRAM BENEFITS APPLY ONLY TO MODEL YEARS 1975 THROUGH 2020
 ATTENTION: THE DEFAULT VALUE OF 50% FOR TECHNOLOGY 4
 I/M IDENTIFICATION RATE HAS BEEN LEFT UNCHANGED

VEH TYPE	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	ALL VEH
VEH SPD	21.0	21.0	21.0		21.0	21.0	21.0	21.0	21.0	
VEH MIX	0.713	0.074	0.037		0.038	0.087	0.011	0.030	0.010	

COMPOSITE EMISSION FACTORS (GM/MILE)
 EXHST CO 42 97 51 59 53 57 52 24 119 11 1.61 2.58 13.28 41.39 41 97

CAL YEAR: 1990 REGION: 49-STATE LOWALT ALT: 500 FT
 TAMB: 33.0(F) 50.0/ 10.0/ 50.0
 LDGV I/M PROGRAM STARTING IN 1984
 STRINGENCY LEVEL 15% MECH TRAINING NO
 I/M PROGRAM BENEFITS APPLY ONLY TO MODEL YEARS 1975 THROUGH 2020
 ATTENTION: THE DEFAULT VALUE OF 50% FOR TECHNOLOGY 4
 I/M IDENTIFICATION RATE HAS BEEN LEFT UNCHANGED

VEH TYPE	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	ALL VEH
VEH SPD	22.0	22.0	22.0		22.0	22.0	22.0	22.0	22.0	
VEH MIX	0.713	0.074	0.037		0.038	0.087	0.011	0.030	0.010	

COMPOSITE EMISSION FACTORS (GM/MILE)
 EXHST CO 41 44 49 74 51 52 50 33 113 22 1.53 2.45 12.65 39.51 40 40

CAL YEAR: 1990 REGION: 49-STATE LOWALT ALT: 500 FT
 TAMB: 33.0(F) 50.0/ 10.0/ 50.0
 LDGV I/M PROGRAM STARTING IN 1984
 STRINGENCY LEVEL 15% MECH TRAINING NO
 I/M PROGRAM BENEFITS APPLY ONLY TO MODEL YEARS 1975 THROUGH 2020
 ATTENTION: THE DEFAULT VALUE OF 50% FOR TECHNOLOGY 4
 I/M IDENTIFICATION RATE HAS BEEN LEFT UNCHANGED

VEH TYPE	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	ALL VEH
VEH SPD	24.0	24.0	24.0		24.0	24.0	24.0	24.0	24.0	
VEH MIX	0.713	0.074	0.037		0.038	0.087	0.011	0.030	0.010	

COMPOSITE EMISSION FACTORS (GM/MILE)
 EXHST CO 38 45 46 13 47 62 46 62 102 98 1.40 2.24 11 53 36 15 37 38

CAL YEAR: 1990 REGION: 49-STATE LOWALT ALT: 500 FT
 TAMB: 33.0(F) 50.0/ 10.0/ 50.0
 LDGV I/M PROGRAM STARTING IN 1984
 STRINGENCY LEVEL 15% MECH TRAINING NO
 I/M PROGRAM BENEFITS APPLY ONLY TO MODEL YEARS 1975 THROUGH 2020
 ATTENTION: THE DEFAULT VALUE OF 50% FOR TECHNOLOGY 4
 I/M IDENTIFICATION RATE HAS BEEN LEFT UNCHANGED

VEH TYPE	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	ALL VEH
VEH SPD	26.0	26.0	26.0		26.0	26.0	26.0	26.0	26.0	
VEH MIX	0.713	0.074	0.037		0.038	0.087	0.011	0.030	0.010	

COMPOSITE EMISSION FACTORS (GM/MILE)
 EXHST CO 35 55 42 64 43 94 43 07 94 49 1.28 2.05 10.59 33.21 34 52

CAL YEAR: 1990 REGION: 49-STATE LOWALT ALT: 500 FT
 TAMB: 33.0(F) 50.0/ 10.0/ 50.0
 LDGV I/M PROGRAM STARTING IN 1984
 STRINGENCY LEVEL 15% MECH TRAINING NO
 I/M PROGRAM BENEFITS APPLY ONLY TO MODEL YEARS 1975 THROUGH 2020
 ATTENTION: THE DEFAULT VALUE OF 50% FOR TECHNOLOGY 4
 I/M IDENTIFICATION RATE HAS BEEN LEFT UNCHANGED

VEH TYPE	LDGV	LDGT1	LDGT2	LDGT	HDGV	LDDV	LDDT	HDDV	MC	ALL VEH
VEH SPD	28.0	28.0	28.0		28.0	28.0	28.0	28.0	28.0	
VEH MIX	0.713	0.074	0.037		0.038	0.087	0.011	0.030	0.010	

COMPOSITE EMISSION FACTORS (GM/MILE)
 EXHST CO 32 78 39 33 40 50 39 71 87 47 1.19 1.90 9 80 30 60 31 85

INTERNATIONAL PLACE - 1983 VAD - I&M

* TOTAL HC EMISSION FACTORS INCLUDE EVAP HC EMISSION FACTORS

CAL. YEAR: 1990 REGION: 49-STATE LOWALT ALT: 500 FT
 TAMB: 33.0(F) 20.6/ 27.3/ 20.6
 LDGV I/M PROGRAM STARTING IN 1984
 STRINGENCY LEVEL 15% MECH TRAINING: NO
 I/M PROGRAM BENEFITS APPLY ONLY TO MODEL YEARS 1975 THROUGH 2020
 ATTENTION: THE DEFAULT VALUE OF 50% FOR TECHNOLOGY 4
 I/M IDENTIFICATION RATE HAS BEEN LEFT UNCHANGED

VEH. TYPE:	LDGV	LDGT1	LDGT2	LDGT	HOGV	LDDV	LDDT	HDDV	MC	ALL VEH
VEH. SPD:	25.0	25.0	25.0		25.0	25.0	25.0	25.0	25.0	
VMT MIX:	0.713	0.074	0.037		0.038	0.087	0.011	0.030	0.010	

COMPOSITE EMISSION FACTORS (GM/MILE)
 EXHST CO: 25.54 28.82 29.82 29.15 98.53 1.17 1.88 11.04 22.16 25.90

CAL. YEAR: 1990 REGION: 49-STATE LOWALT ALT: 500 FT
 TAMB: 33.0(F) 20.6/ 27.3/ 20.6
 LDGV I/M PROGRAM STARTING IN 1984
 STRINGENCY LEVEL 15% MECH TRAINING: NO
 I/M PROGRAM BENEFITS APPLY ONLY TO MODEL YEARS 1975 THROUGH 2020
 ATTENTION: THE DEFAULT VALUE OF 50% FOR TECHNOLOGY 4
 I/M IDENTIFICATION RATE HAS BEEN LEFT UNCHANGED

VEH. TYPE:	LDGV	LDGT1	LDGT2	LDGT	HOGV	LDDV	LDDT	HDDV	MC	ALL VEH
VEH. SPD:	26.0	26.0	26.0		26.0	26.0	26.0	26.0	26.0	
VMT MIX:	0.713	0.074	0.037		0.038	0.087	0.011	0.030	0.010	

COMPOSITE EMISSION FACTORS (GM/MILE)
 EXHST CO: 24.55 27.70 28.64 28.01 94.49 1.13 1.80 10.59 21.24 24.88

CAL. YEAR: 1990 REGION: 49-STATE LOWALT ALT: 500 FT
 TAMB: 33.0(F) 20.6/ 27.3/ 20.6
 LDGV I/M PROGRAM STARTING IN 1984
 STRINGENCY LEVEL 15% MECH TRAINING: NO
 I/M PROGRAM BENEFITS APPLY ONLY TO MODEL YEARS 1975 THROUGH 2020
 ATTENTION: THE DEFAULT VALUE OF 50% FOR TECHNOLOGY 4
 I/M IDENTIFICATION RATE HAS BEEN LEFT UNCHANGED

VEH. TYPE:	LDGV	LDGT1	LDGT2	LDGT	HOGV	LDDV	LDDT	HDDV	MC	ALL VEH
VEH. SPD:	29.0	29.0	29.0		29.0	29.0	29.0	29.0	29.0	
VMT MIX:	0.713	0.074	0.037		0.038	0.087	0.011	0.030	0.010	

COMPOSITE EMISSION FACTORS (GM/MILE)
 EXHST CO: 21.73 24.52 25.34 24.79 84.44 1.01 1.61 9.45 18.81 22.06

CAL. YEAR: 1990 REGION: 49-STATE LOWALT ALT: 500 FT
 TAMB: 33.0(F) 20.6/ 27.3/ 20.6
 LDGV I/M PROGRAM STARTING IN 1984
 STRINGENCY LEVEL 15% MECH TRAINING: NO
 I/M PROGRAM BENEFITS APPLY ONLY TO MODEL YEARS 1975 THROUGH 2020
 ATTENTION: THE DEFAULT VALUE OF 50% FOR TECHNOLOGY 4
 I/M IDENTIFICATION RATE HAS BEEN LEFT UNCHANGED

VEH. TYPE:	LDGV	LDGT1	LDGT2	LDGT	HOGV	LDDV	LDDT	HDDV	MC	ALL VEH
VEH. SPD:	30.0	30.0	30.0		30.0	30.0	30.0	30.0	30.0	
VMT MIX:	0.713	0.074	0.037		0.038	0.087	0.011	0.030	0.010	

COMPOSITE EMISSION FACTORS (GM/MILE)
 EXHST CO: 20.87 23.55 24.34 23.81 81.69 0.97 1.55 9.13 18.08 21.21

CAL. YEAR: 1990 REGION: 49-STATE LOWALT ALT: 500 FT
 TAMB: 33.0(F) 20.6/ 27.3/ 20.6
 LDGV I/M PROGRAM STARTING IN 1984
 STRINGENCY LEVEL 15% MECH TRAINING: NO
 I/M PROGRAM BENEFITS APPLY ONLY TO MODEL YEARS 1975 THROUGH 2020
 ATTENTION: THE DEFAULT VALUE OF 50% FOR TECHNOLOGY 4
 I/M IDENTIFICATION RATE HAS BEEN LEFT UNCHANGED

VEH. TYPE:	LDGV	LDGT1	LDGT2	LDGT	HOGV	LDDV	LDDT	HDDV	MC	ALL VEH
VEH. SPD:	32.0	32.0	32.0		32.0	32.0	32.0	32.0	32.0	
VMT MIX:	0.713	0.074	0.037		0.038	0.087	0.011	0.030	0.010	

COMPOSITE EMISSION FACTORS (GM/MILE)
 EXHST CO: 19.28 21.76 22.50 22.00 76.96 0.91 1.46 8.57 16.76 19.66

CAL. YEAR: 1990 REGION: 49-STATE LOWALT ALT: 500 FT
 TAMB: 33.0(F) 20.6/ 27.3/ 20.6
 LDGV I/M PROGRAM STARTING IN 1984
 STRINGENCY LEVEL 15% MECH TRAINING: NO
 I/M PROGRAM BENEFITS APPLY ONLY TO MODEL YEARS 1975 THROUGH 2020
 ATTENTION: THE DEFAULT VALUE OF 50% FOR TECHNOLOGY 4
 I/M IDENTIFICATION RATE HAS BEEN LEFT UNCHANGED

VEH. TYPE:	LDGV	LDGT1	LDGT2	LDGT	HOGV	LDDV	LDDT	HDDV	MC	ALL VEH
VEH. SPD:	33.0	33.0	33.0		33.0	33.0	33.0	33.0	33.0	
VMT MIX:	0.713	0.074	0.037		0.038	0.087	0.011	0.030	0.010	

COMPOSITE EMISSION FACTORS (GM/MILE)
 EXHST CO: 18.57 20.96 21.67 21.19 74.95 0.89 1.42 8.33 16.16 18.97

CAL. YEAR: 1990 REGION: 49-STATE LOWALT ALT: 500 FT
 TAMB: 33.0(F) 20.6/ 27.3/ 20.6
 LDGV I/M PROGRAM STARTING IN 1984
 STRINGENCY LEVEL 15% MECH TRAINING: NO
 I/M PROGRAM BENEFITS APPLY ONLY TO MODEL YEARS 1975 THROUGH 2020
 ATTENTION: THE DEFAULT VALUE OF 50% FOR TECHNOLOGY 4
 I/M IDENTIFICATION RATE HAS BEEN LEFT UNCHANGED

VEH. TYPE:	LDGV	LDGT1	LDGT2	LDGT	HOGV	LDDV	LDDT	HDDV	MC	ALL VEH
VEH. SPD:	35.0	35.0	35.0		35.0	35.0	35.0	35.0	35.0	
VMT MIX:	0.713	0.074	0.037		0.038	0.087	0.011	0.030	0.010	

COMPOSITE EMISSION FACTORS (GM/MILE)
 EXHST CO: 17.33 19.56 20.21 19.77 71.55 0.84 1.34 7.91 15.07 17.77

IP PARKING GARAGE ANALYSIS

* TOTAL HC EMISSION FACTORS INCLUDE EVAP. HC EMISSION FACTORS

CAL. YEAR: 1984 REGION: 49-STATE LOWALT ALT: 500. FT
TAMB: 33.0(F) 100 0/ 0 0/100 0LDGV I/M PROGRAM STARTING IN 1984
STRINGENCY LEVEL 15% MECH TRAINING: NO
I/M PROGRAM BENEFITS APPLY ONLY TO MODEL YEARS 1969 THROUGH 2020
ATTENTION: THE DEFAULT VALUE OF 50% FOR TECHNOLOGY 4
I/M IDENTIFICATION RATE HAS BEEN LEFT UNCHANGED

VEH TYPE:	LDGV	LDGT1	LDGT2	LDGT	HOGV	LDDV	LDDT	HDDV	MC	ALL VEH
VEH SPD:	5 0	5 0	5 0		5 0	5 0	5 0	5 0	5 0	
VMT MIX:	0 776	0 081	0 037		0 039	0 025	0 003	0 030	0 010	

COMPOSITE EMISSION FACTORS (GM/MILE)

EXHST CO: 557.27 581 91 738 57 631 17 736 71 6.26 9 67 37 17 363.35 540 19

CAL. YEAR: 1984 REGION: 49-STATE LOWALT ALT: 500. FT
TAMB: 33.0(F) 0 0/ 0 0/ 0 0LDGV I/M PROGRAM STARTING IN 1984
STRINGENCY LEVEL 15% MECH TRAINING: NO
I/M PROGRAM BENEFITS APPLY ONLY TO MODEL YEARS 1969 THROUGH 2020
ATTENTION: THE DEFAULT VALUE OF 50% FOR TECHNOLOGY 4
I/M IDENTIFICATION RATE HAS BEEN LEFT UNCHANGED

VEH TYPE:	LDGV	LDGT1	LDGT2	LDGT	HOGV	LDDV	LDDT	HDDV	MC	ALL VEH
VEH SPD:	5 0	5 0	5 0		5 0	5 0	5 0	5 0	5 0	
VMT MIX:	0 776	0 081	0 037		0 039	0 025	0 003	0 030	0 010	

COMPOSITE EMISSION FACTORS (GM/MILE)

EXHST CO: 135 90 131.16 169.34 143 16 736.71 2.93 4.52 37.17 81.26 152.72

IP PARKING GARAGE ANALYSIS

* TOTAL HC EMISSION FACTORS INCLUDE EVAP HC EMISSION FACTORS

CAL YEAR 1990 REGION: 49-STATE LOWALT ALT: 500 FT
TAMB: 33.0(F) 100.0/ 0 0/100.0
LDGV I/M PROGRAM STARTING IN 1984
STRINGENCY LEVEL 15% MECH. TRAINING: NO
I/M PROGRAM BENEFITS APPLY ONLY TO MODEL YEARS 1975 THROUGH 2020
ATTENTION: THE DEFAULT VALUE OF 50% FOR TECHNOLOGY 4
I/M IDENTIFICATION RATE HAS BEEN LEFT UNCHANGED

VEH TYPE:	LDGV	LDGT1	LDGT2	LDGT	HOGV	LDDV	LDGT	HODV	MC	ALL VEH
VEH SPD:	5.0	5.0	5.0		5.0	5.0	5.0	5.0	5.0	
VMT MIX:	0.713	0.074	0.037		0.038	0.087	0.011	0.030	0.010	

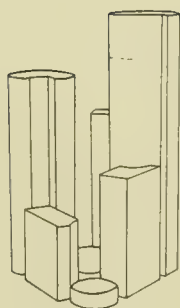
COMPOSITE EMISSION FACTORS (GM/MILE)
EXHST CO: 238.77 304.91 352.00 326.48 361.55 6.43 10.28 37.17 349.95 224.81

CAL YEAR: 1990 REGION: 49-STATE LOWALT ALT: 500 FT
TAMB: 33.0(F) 0 0/ 0 0/ 0.0
LDGV I/M PROGRAM STARTING IN 1984
STRINGENCY LEVEL 15% MECH. TRAINING: NO
I/M PROGRAM BENEFITS APPLY ONLY TO MODEL YEARS 1975 THROUGH 2020
ATTENTION: THE DEFAULT VALUE OF 50% FOR TECHNOLOGY 4
I/M IDENTIFICATION RATE HAS BEEN LEFT UNCHANGED.

VEH TYPE:	LDGV	LDGT1	LDGT2	LDGT	HOGV	LDDV	LDGT	HODV	MC	ALL VEH
VEH SPD:	5.0	5.0	5.0		5.0	5.0	5.0	5.0	5.0	
VMT MIX:	0.713	0.074	0.037		0.038	0.087	0.011	0.030	0.010	

COMPOSITE EMISSION FACTORS (GM/MILE)
EXHST CO: 74.77 80.21 90.48 83.60 361.55 2.99 4.78 37.17 77.91 78.66

Pedestrian Wind Analysis



II. Pedestrian Wind Analysis of International Place,
Boston

for

The Chiofaro Company
One Post Office Square
Suite 3100
Boston, Massachusetts 02109

by

J. A. Peterka* and J. E. Cermak**

Fluid Mechanics and Wind Engineering Program
Fluid Dynamics and Diffusion Laboratory
Department of Civil Engineering
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Fort Collins, Colorado 80523

CSU Project 2-95820

May 1984

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**Professor-in-Charge, Fluid Mechanics

and Wind Engineering Program

CER83-84JAP-JEC35B

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TECHNICAL APPENDICES

1. INTRODUCTION

During the initial stages of the design process for International Place the importance of designing to minimize potential for wind problems became apparent to the project sponsors. Fort Hill Square Associates interviewed several wind engineering consultants before selecting J.A. Peterka and J.E. Cermak of Colorado State University to be the wind engineers for the project. The authors were selected based upon their extensive experience and their international reputation for excellence in analyzing the wind effects of high-rise urban developments. In total, the wind engineering study team has provided wind engineering for some 175 similar projects worldwide.

The authors have been charged with providing support to the project through five phases of design development, all of which are now complete. The first phase of wind engineering consisted of a subjective conceptual design review of the project site and the building elements as depicted in scale models. Relying primarily on professional judgment and past experience the likely wind effects of the various building elements were hypothesized. The project sponsors were given advice as to effects of various building heights, shapes and activity centers. Suggestions for minimizing potential wind problems were offered and considered in the context of overall design goals and feasibility. Design changes primarily involved shrinking the size of rectangular building elements

The second phase of wind engineering was the qualitative wind tunnel testing. This phase consisted of observing "smoke test" flow patterns associated with International Place and its surroundings. While the smoke tests had several objectives the primary purposes of these

initial wind tunnel tests were to identify building elements and ground level locations which warranted more detailed study in the subsequent quantitative analysis.

The third phase of the wind engineering effort was a quantitative wind tunnel modeling study. The scale model of the project was outfitted with hot wire sensors at 47 ground level locations chosen in the qualitative testing. Tests were run with historical Boston wind speed and direction data simulated in the wind tunnel. Resultant frequencies of occurrence of various wind speeds at the 47 ground level locations were recorded with and without International Place. The wind tunnel data were analyzed and the significance of the data described.

During the fourth phase of wind engineering the study team reviewed the sites at which relatively high winds were predicted. Means for reducing wind speeds at these locations were postulated and tested in the wind tunnel. Phase four culminated with the compilation of a set of recommended mitigating measures.

The fifth and final phase of wind engineering is the structural analysis of selected elements of the project. This phase, which is the only phase of studies not documented in this report.

The subsequent sections of the wind analysis report address, sequentially, six topics. Section 2 describes the nature of urban winds, providing some basis for understanding how and why a project like International Place can affect local winds. Section 3 is a discussion of the wind significance criteria used to measure potential for wind impacts in this report. Wind study methodology is outlined in Section 4. This discussion includes a description of the wind tunnel facility used and the data and assumptions incorporated in the analysis.

Sections 5, 6 and 7 describe the qualitative wind tunnel analysis, the quantitative wind tunnel analysis and the mitigation analysis, respectively.

2. NATURE OF URBAN WINDS

2.1 General

The winds blowing over the earth's surface are slowed and mixed by interaction with trees, buildings, and other features which contribute to "surface roughness." The result of this interaction is that the average wind speeds increase with elevation above the local terrain up to a level called the gradient height (usually 275 to 400 m, or 900 to 1,350 ft.). Above this level, the wind speed is relatively constant and unaffected by the surface development. This region below the gradient height where the surface roughness affects the wind characteristics is known as the atmospheric boundary layer.

In an urban environment there is a potential for the natural wind field in the boundary layer to be modified in the following ways as it interacts with obstacles:

- a. Vertical deflection of upper level winds towards the ground on the windward side of tall buildings. As winds flow perpendicular to the vertical faces of high rise buildings, pressure gradients may be created. Higher pressure is created by the winds of greater velocity nearer the gradient height, with lower pressure near ground level.---The pressure gradient deflects the winds of higher velocity, normally associated with higher elevations, down to pedestrian level. High wind speeds at ground level are most pronounced near tall buildings which are surrounded by structures whose heights are low in comparison to the tall building. Examples of this situation in Boston include the Prudential and John Hancock

Towers. At ground level, the highest winds are often found around building corners. This corner flow is usually steady high-speed wind that changes to a lower speed but gusty wind as it moves farther from the building.

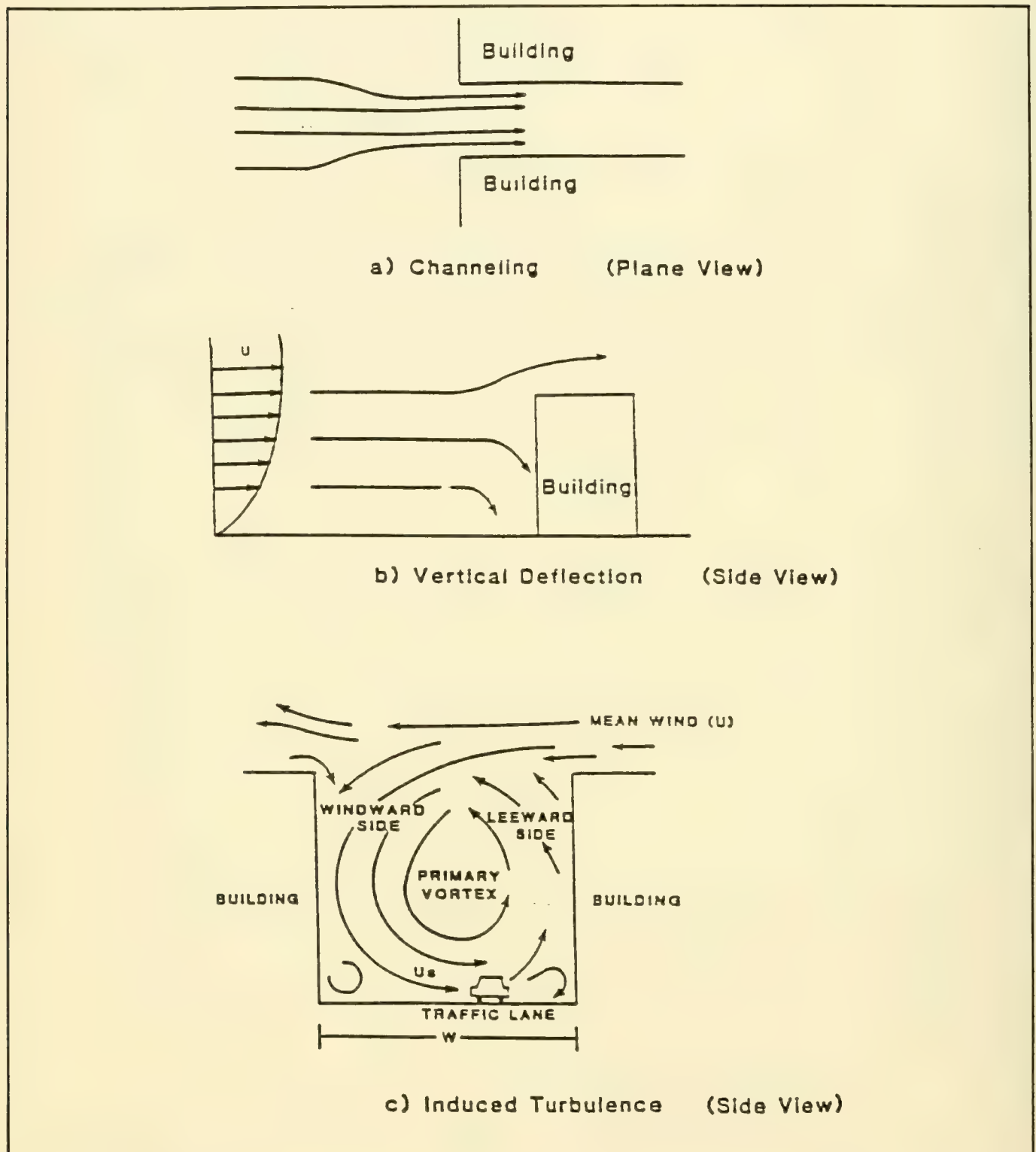
- b. Channeling of the air stream between buildings. Buildings with parallel facades may "channel" winds. As winds are compressed to fit through the openings between buildings they are accelerated. Channeling increases winds within the channel formed. It also creates likely "hot spots" for increased wind gusts at the corners of the channels.
- c. Induced turbulence on the leeward side of buildings. As winds flow perpendicular to urban street canyon sections vortexes may be created. This results in some potential for increased winds swirling in a vertical plane roughly parallel to the prevailing wind direction. Increased winds may occur in eddies on both the windward and lee sides of the street canyon downwind of a building.

These three influences, which result in increased wind levels or gustiness, are depicted in in Figure 2.1. These influences affect both the comfort level of individuals on city streets, and engineering design aspects for pedestrian entryways, supports of street signs, and signal lights.

2.2 Boston Wind Climate

Wind data for Boston have been compiled for many years. Perhaps the most comprehensive wind data base has been

Figure 2.1 Schematic of Urban Environment on the Wind Field



obtained from measurements recorded at the Logan International Airport National Weather Service (NWS) station. The data collected at this station indicates that Boston is, in general, a windy city. Average annual winds are 12.6 mph, with winds of 32 mph occurring on at least one day per month*. Winds are slightly stronger in the winter months, from December through March, and lighter in the peak summer months. In addition, long-term wind data demonstrates the prevailing wind direction to be, approximately, from the westerly direction.

* NOAA, Local Climatological Data, Annual Summary and Comparative Data: Boston, Massachusetts, National Climatic Center, Asheville, NC 1980.

3. WIND SIGNIFICANCE CRITERIA

Many different wind engineers have attempted to develop criteria for measuring the significance of various wind speeds. The first credible attempt at developing wind criteria is probably the Beaufort Scale developed by Admiral Beaufort based upon his 19th century observations. Contemporary wind significance criteria have been suggested by Davenport (1972), Lawson (1973), Penwarden & Wide (1975), Hunt, Poulton & Mumford (1976), and Melbourne (1978)

The various criteria can often be quite confusing. Some are based upon average wind speeds, others upon wind gust speeds. Some are based upon frequency of occurrence of wind speeds, others are based upon type of activity to be accommodated. Many are based on combinations of these factors. All are influenced by the judgment of the authors and the windiness of the environment to which he and his test populations are normally exposed. In short acceptability of winds, like temperature, may vary considerably from region to region and from person to person.

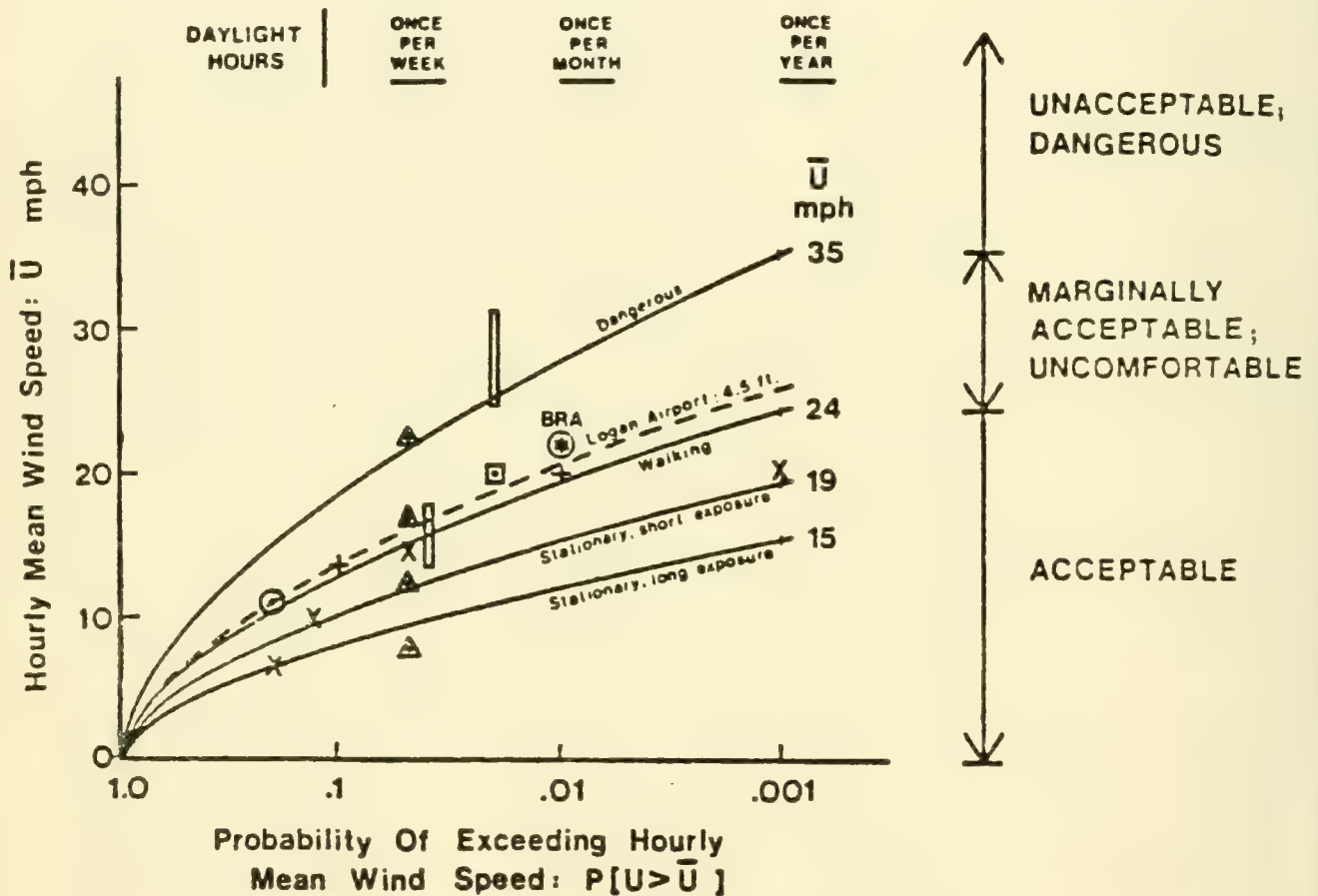
To measure the significance of wind levels near the International Place site two criteria have been considered. The first, and primary criterion, is the informal BRA wind design guidance level. BRA has suggested that effective gust velocities (defined as average hourly wind speeds + 1.5 root mean square) exceeded 1% of the time should be ≤ 31 mph. This criterion was selected as the primary criterion since it reflects local perceptions of acceptable wind levels, and because it is a relatively straight-forward, easily interpreted design guideline. The supplementary criteria are the Melbourne "International Pedestrian Comfort Criteria" depicted in

Figure 3.1. These are probabilistic criteria for hourly average pedestrian winds for a variety of human activities. The vertical scale is the average hourly velocity in miles per hour; the horizontal scale is the frequency of occurrence of the wind speed. The four curves on the graph separate five comfort zones. The upper zone represents hazardous wind speeds, the second zone indicates wind speeds that may be safe but uncomfortable for walking, the third zone indicates comfortable walking environment; the fourth zone indicates wind speeds low enough to accommodate short term stationary exposures, and the fifth and final zone indicates wind speeds acceptable to accommodate long-term stationary activities. As points of references two additional features have been added to the graphical representation of the Melbourne criteria. One is the BRA criterion, adjusted to be a mean wind speed rather than an effective gust velocity (i.e., $U + 1.5 \text{ RMS} @ 31 \text{ mph} = U @ 23 \text{ mph}^*$).

The BRA criterion fits within the bottom of the second Melbourne zone - safe but uncomfortable for walking. The second feature added to the graph is the dotted curve representative of average wind speed data observed at Logan Airport. This curve also fits within the "safe but uncomfortable for walking" zone, just below the BRA criterion. Wind speeds above the dotted line indicate conditions in which urban design elements have increased wind levels; levels below the dotted line indicate that urban landscape features have reduced ambient wind levels. From these data it may be correctly inferred that Boston is an extremely windy city. Small changes in the

* $U/U_{\text{inf}} = 0.45$ and $U_{\text{rms}}/U_{\text{inf}} = 0.11$

Figure 3.1 Melbourne's Criteria for Average Hourly Pedestrian Winds Compared With Other References



Reference: Skidmore, Owings & Merrill, Rowes Wharf Development Final Environmental Impact Report, EOE #4992, July, 1984.

natural wind field can result in exceedances of the BRA criterion or even the hazardous wind levels suggested by the Melbourne International Pedestrian Comfort Criteria. Accordingly, care must be taken in applying the wind significance criteria, and in interpreting the significance of wind levels in Boston*

* Note for example that the authors of this report feel that the Melbourne curves are less accurate when frequency of occurrence is $>.1$ or $<.005$.

4. WIND STUDY METHODOLOGY

4.1 General

Modeling of aerodynamic loading and wind flow characteristics for a structure requires special consideration of flow conditions in order to assure that conditions modeled are representative of the project being studied. A detailed discussion of the requirements for the similarity of the model to actual conditions and their wind-tunnel implementation can be found in the references below. In general, the requirements are that the model and prototype be geometrically similar, that the approach mean velocity of the winds modeled at the building site have a vertical profile shape similar to the full-scale flow, that the turbulence characteristics of the flows be similar, and that the Reynolds number for the model and prototype be equal. Reynolds number represents the ratio of inertial forces to frictional forces on an air parcel. The requirement that this ratio be equal (between the model and prototype) is to ensure similarity of turbulent flow patterns. These criteria are satisfied by constructing a scale model of the structure and its surroundings and performing the wind tests in a wind tunnel specifically designed to model atmospheric boundary-layer flows.

1. Cermak, J.E., "Laboratory Simulation of the Atmospheric Boundary Layer," AIAA J1., Vol. 9, September 1971.
2. Cermak, J.E., "Applications of Fluid Mechanics to Wind Engineering," A Freeman Scholar Lecture, ASME J1. of Fluids Engineering, Vol. 97, No. 1, March 1975.
3. Cermak, J.E., "Aerodynamics of Buildings," Annual Review of Fluid Mechanics, Vol. 8, 1976, pp. 75-106.

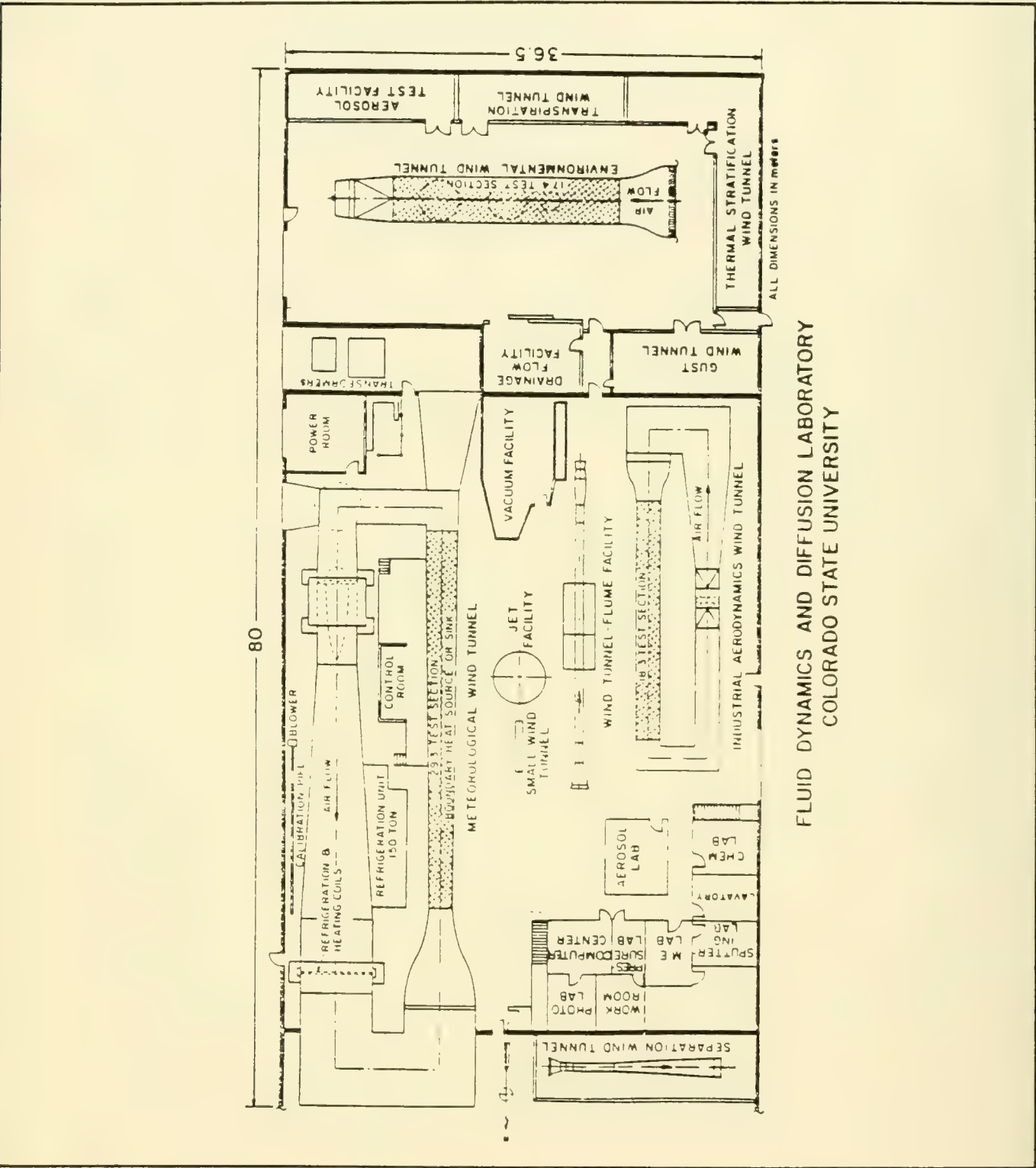
4.2 Description of Wind Tunnel and Model

Wind-engineering studies were performed in the Fluid Dynamics and Diffusion Laboratory at Colorado State University (Figure 4.1). Three large wind tunnels are available for wind loading studies depending on the detailed requirements of the study. The environmental wind tunnel used for this investigation is shown in Figure 4.2. The wind tunnel has a flexible roof adjustable in height to maintain a zero horizontal pressure gradient along the test section. The mean velocity in the environmental wind tunnel can be adjusted continuously to a maximum velocity of 35 feet per second. This speed is more than adequate to satisfy model wind flow similarity requirements discussed above.

A scale model of the surroundings was constructed at a scale of 1:384 ($1/32" = 1 \text{ ft}$) to a distance of 1800 ft from the site. The model was constructed from styrofoam and wood and included the elevated Central Artery. A detailed model of the project site, including current massing for the project, was supplied by the architect.

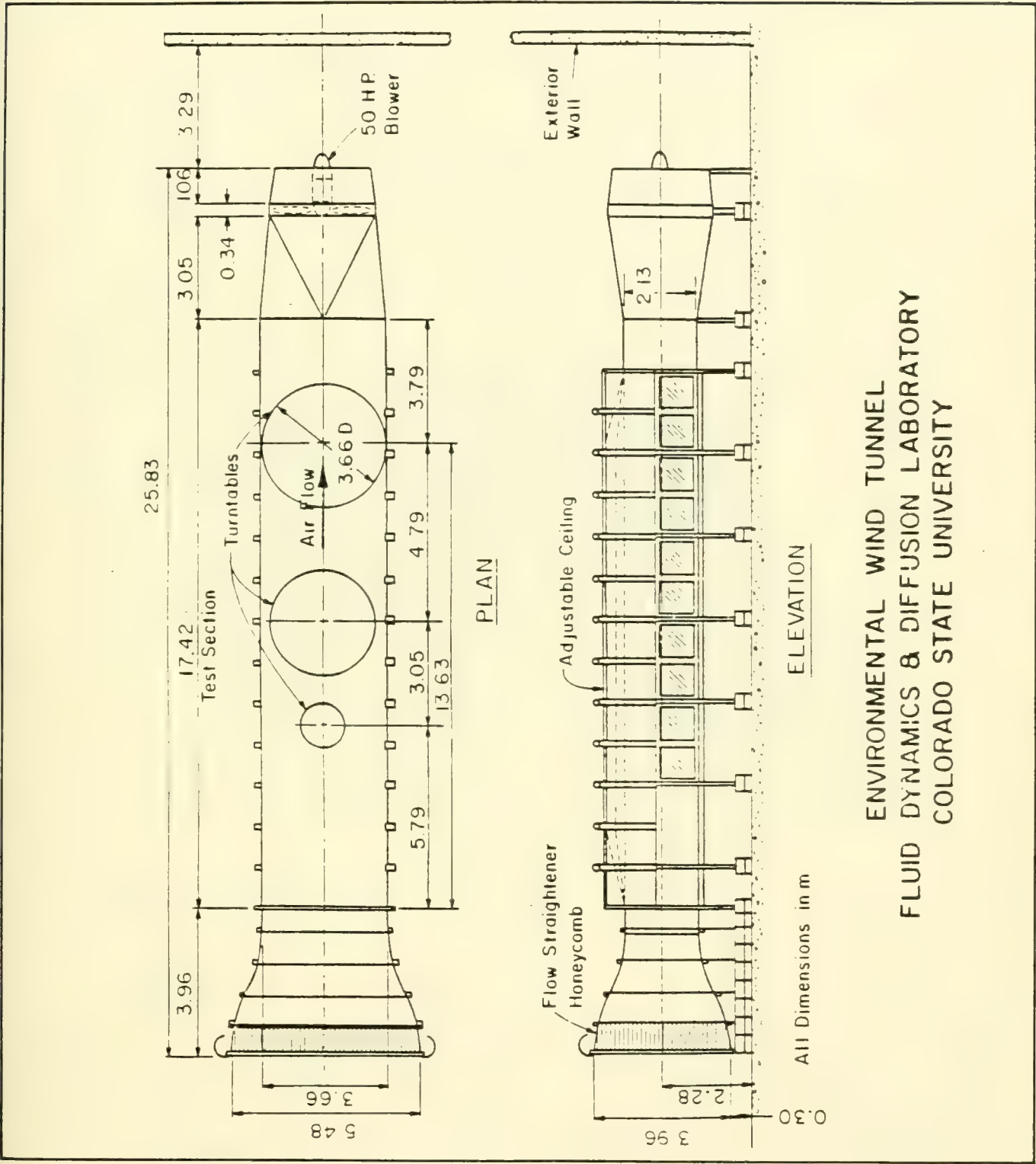
The region in the wind tunnel upstream from the modeled area was covered with a randomized roughness constructed using cubes placed on the floor of the wind tunnel. Spires were installed at the test-section entrance to provide a thicker boundary layer than would otherwise be available. The thicker boundary layer permitted a somewhat larger scale model than would otherwise be possible. The spires were approximately triangularly shaped pieces of $1/2 \text{ in.}$ thick plywood 6 in. wide at the base and 1 in. wide at the top, extending from the floor to the top of the test section. They were placed so that the broad side intercepts the flow. A barrier approximately 8 in. high was placed on the

Figure 4.1 Fluid Dynamics and Diffusion Laboratory



International
Place
at Fort Hill

Figure 4.2 Wind Tunnel Configuration



ENVIRONMENTAL WIND TUNNEL
FLUID DYNAMICS & DIFFUSION LABORATORY
COLORADO STATE UNIVERSITY

International
Place
at Fort Hill

test-section floor downstream of the spires to aid in development of the boundary-layer flow.

The distribution of the roughness cubes and the spires in the roughened area was designed to provide a boundary-layer thickness of approximately 40 in., a wind velocity profile power-law exponent similar to that expected to occur in the region approaching the modeled area for each wind direction (a number of wind directions may have the same approach roughness). A photograph of the completed model in the wind tunnel is shown in Figure 4.3. The wind-tunnel ceiling was adjusted, after placement of the model, to obtain a zero horizontal pressure gradient thus approximating actual conditions.

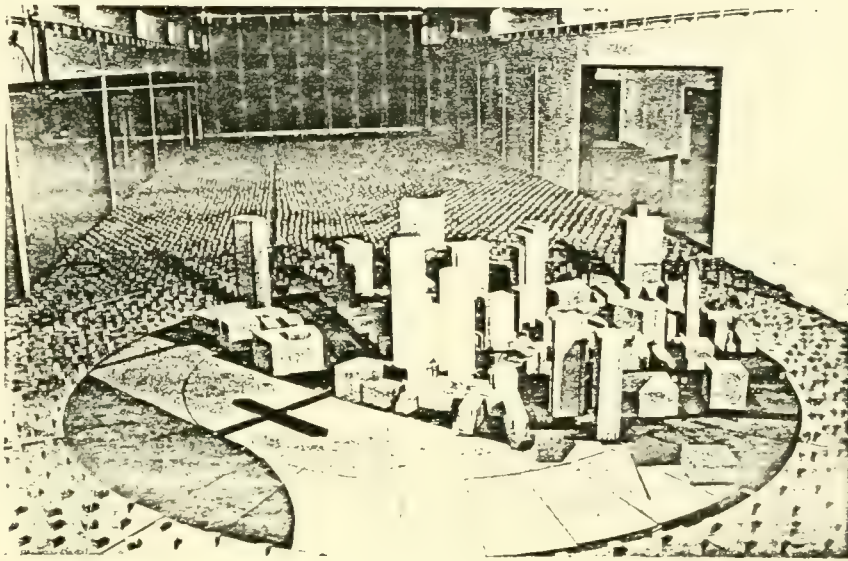
The entire city model was mounted on a turntable so that it could be rotated to any desired wind direction. This enabled the project area, with and without International Place, to be modeled for different wind exposures in both the qualitative and quantitative analyses.

4.3 Wind Exposure Profiles

Four different approach profiles for wind were studied. They were:

<u>Profile</u>	<u>Wind Directions</u>	<u>Power Law Exponent</u>
A)	25-125 ⁰	0.16
B)	125-215 ⁰	0.23
C)	215-360 ⁰ , 0-25 ⁰	0.30
D)	0-360 ⁰	0.27

Figure 4.3 Completed Model in the Wind Tunnel



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The approach profiles "A", "B", and "C" were utilized in the quantitative analysis to account for different upstream roughness. Wind profile "A" represents air flow over an open area as found to the east of Fort Hill where winds are largely unshielded as they come in over Boston Harbor. Profile "B" is typical of winds having low buildings upstream as found across Fort Point Channel from the project site. Wind profile "C" provides a representation of winds at the site where the upstream air flow is over high-rise structures as found to the north and west of International Place.

For the qualitative analysis, experience has shown that in a flow visualization study using smoke for a tracer, no differentiation can be made in flow characteristics for mode changes in approach profile. Thus, a single approach profile ("D") of $\alpha = 0.27$ was selected to represent all three approach characteristics.

4.4 Wind Definition

Location of National Weather Service anemometers at Logan International Airport provides a good source of wind data which is in an open area away from significant influence of buildings but close enough to the City of Boston to have winds representative of the City. The airport has three basic sources of wind data: 1) hourly data from an anemometer at 22 feet above ground which provides representation data set for pedestrian level winds, 2) fastest mile data from an anemometer which varied in elevation from 22 feet to 62 feet in elevation which provides low probability event data not present in the hourly data at 22 feet, and 3) pilot balloon wind profile data which provides information primarily on winds at the top of the atmospheric boundary layer.

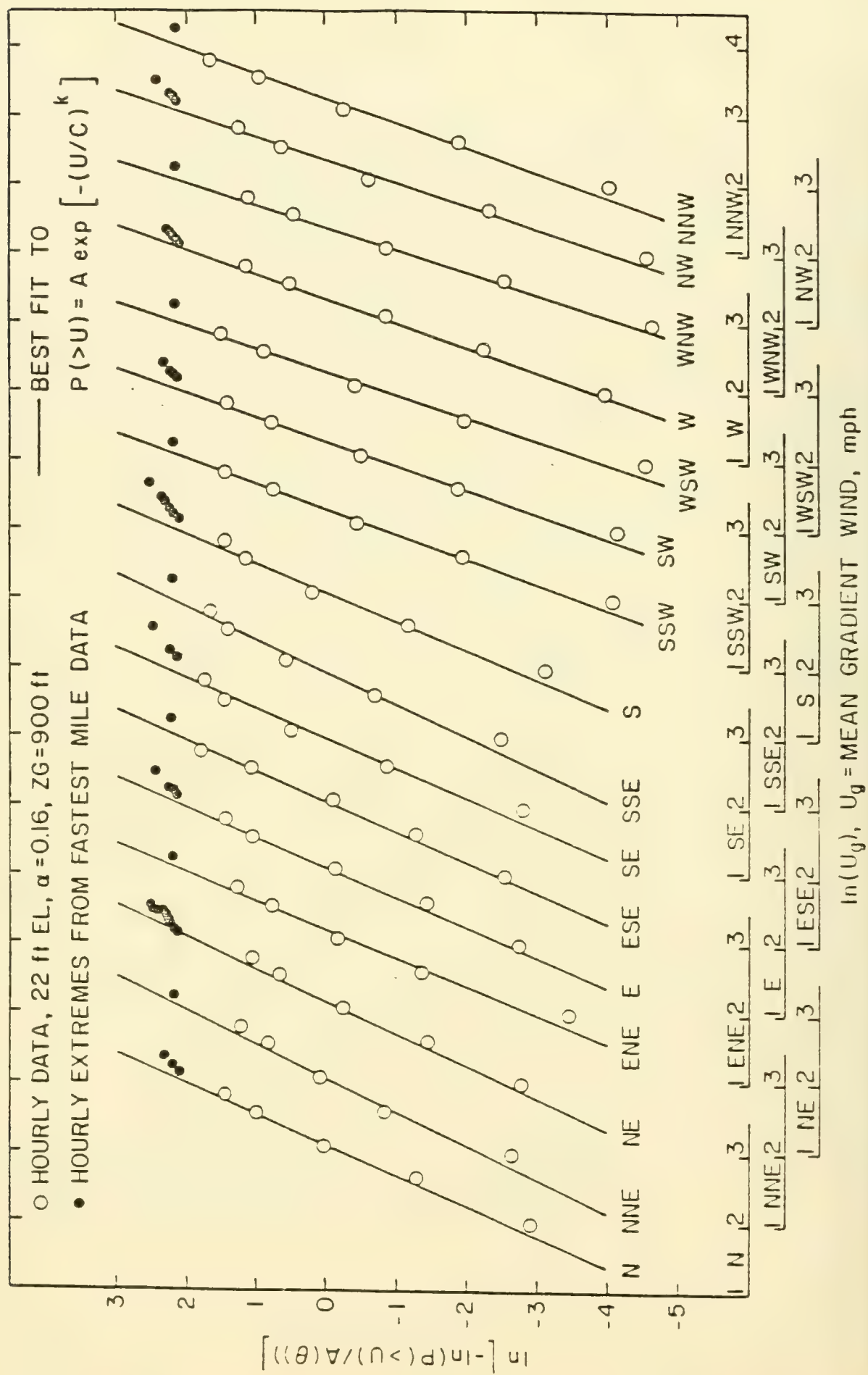
An analysis of the surface winds was made to determine the consistency of the hourly and fastest mile wind data and to determine its applicability for use for pedestrian wind analysis and structural loading. Figure 4.4 shows the results of that analysis. The data points are the cumulative distribution of winds by direction (open circles) and individual fastest mile wind events (solid circles). The hourly data were translated to a gradient height of 900 feet with a 0.16 power law exponent. The fastest mile wind data were converted to an equivalent hourly wind using gust factors*, and translated to a gradient height of 900 feet with a 0.16 power law. Thus, both sets of data were brought to a common time average and elevation. In actuality, the hourly data are not true hourly averages but are one-minute averages obtained once an hour, on the hour. The best estimate of the hourly mean from those samples is the sample value, although some samples will obviously be too high or low.

The fastest mile events shown in Figure 4.4 were established by obtaining the highest, fastest mile for each of 8 wind directions for 42 years of record from the National Climatic Center, Asheville, North Carolina. The 336 resulting values, corrected to hourly mean at gradient level, were ordered from highest to lowest and assigned probabilities of

$$P_i = \frac{i}{N + 1}$$

* Hollister, S.C., "The Engineering Interpretation of Weather Bureau Records for Wind Loading on Structures," Building Science Series 30-Wind Loads on Buildings and Structures, National Bureau of Standards, 1970, pp. 151-164.

Figure 4.4 Wind Speeds in Boston by Direction



where i is the order number of the sample and $N = 367,920$, the total number of hours in the 42 year record. By using only the 95 largest values, the resulting velocity/probability combinations should reasonably represent the low probability events of fastest mile data. The data plotted in Figure 4.4 show that the fastest mile data form a continuous curve with the hourly data. Since fastest mile data was only available at 8 wind directions, the values at intermediate directions were interpolated.

The probabilistic model fit to the data shown in Figure 4.4 was, for each wind direction, a Weibull distribution:

$$P(>U) = A e^{-\left(\frac{U}{c}\right)^k}$$

where A , c and k are constants. The value of A represents the fraction of time the wind blows from each of the 16 directions considered and was obtained from the published distribution of hourly data. The sum of A 's from all wind directions was required to equal 1.0, a necessary condition for a consistent probability definition. The values of c and k were obtained by least squares fit.

Examination of Figure 4.4 shows that the data points do not follow precisely a straight line but have a definite curvature. This same curvature has been identified by Rijkooort* to be due to atmospheric stability effects.

* Rijkooort, P.J., "A Compound Weibull Model for the Description of Surface Wind Velocity Distributions," Scientific Report W.R. 83-13, Koninklijk Nederlands Meteorologisch Instituut, 1983.

Because of the significant stability effects noted above in the surface data, it is more accurate to use this data (22 feet) translated to gradient height for pedestrian winds than to use measured gradient level winds which do not show these effects. For the pedestrian wind analysis, the surface data was used with linear interpolation between data points, rather than the analytical fit to be sure that all characteristics of the probability distribution were properly included. The base surface data utilized in the analysis is presented in Table 4.1. The translation of surface data to gradient level did not distort the probability distribution since this translation used the same neutral boundary layer characteristics which were used in the wind tunnel.

Table 4.1

PERCENTAGE FREQUENCY OF WIND DIRECTION AND SPEED											
GENERAL LOUGH INTERNATIONAL AIRPORT											
(1955-1974)											
DIRECTION	NO OF OBS	NO OF MEAS	FT	0-7	8-12	13-18	19-24	25-31	32-38	39-45	TOTAL
0-7	30	1	40	1	3	2	4	10	0	0	2
8-12	20	1	50	1	3	2	3	10	0	0	3
13-18	20	1	70	1	3	1	2	2	0	0	3
19-24	30	1	90	1	3	2	2	10	0	0	3
25-31	30	1	100	1	3	2	2	10	0	0	3
32-38	30	1	110	1	3	2	2	10	0	0	3
39-45	30	1	120	1	3	2	2	10	0	0	3
46-52	30	1	130	1	3	2	2	10	0	0	3
53-59	30	1	140	1	3	2	2	10	0	0	3
60-66	30	1	150	1	3	2	2	10	0	0	3
67-73	30	1	160	1	3	2	2	10	0	0	3
74-80	30	1	170	1	3	2	2	10	0	0	3
81-87	30	1	180	1	3	2	2	10	0	0	3
88-94	30	1	190	1	3	2	2	10	0	0	3
95-101	30	1	200	1	3	2	2	10	0	0	3
TOTAL	300	14	2000	14	39	36	36	130	40	10	300

5. QUALITATIVE ANALYSIS

5.1 Introduction

The qualitative analysis involved visually observing wind flow patterns associated with International Place utilizing a smoke tracer. The objectives of the analysis were as follows:

1. Provide general conclusions on the nature of the wind environment in the project site area.
2. Describe, qualitatively, the nature and locations of project-related changes in the wind environment.
3. Test the relative difference in wind environment associated with various phases of project development.
4. Compare the wind environment at the International Place site to wind conditions adjacent to other tall buildings in Boston.
5. Investigate potential for affecting local dispersion of air pollutants, and
6. Provide information for selecting study locations for the Quantitative Analysis which details wind impacts in absolute terms.

These objectives were accomplished through visual observations of "smoke testing" in the wind tunnel under a variety of wind speeds and directions.

5.2. Study Approach

Pedestrian level winds were studied in an atmospheric boundary layer wind tunnel utilizing flow visualization techniques with a smoke tracer of TiO_2 . The methodology involved observing wind flow patterns at ground level in the study area with a smoke probe. A model of the proposed site and surroundings was developed at a scale of 1:384.

Flow visualization with a smoke tracer was performed for a radial distance of 1,500 feet (full scale) around the proposed site (see Figure 5.1). The following five construction configurations were examined:

- PRE - preconstruction configuration (Figure 5.2)
- PH1 - Phase 1 tower (south tower) and part of the lowrise (Figure 5.3)
- PH2 - complete project including south tower, north tower and lowrise structures (Figure 5.4)
- PH1F - configuration PH1 with replacement of the free-way with three 140 foot buildings (Figure 5.5)
- PH2F - configuration PH2 with replacement of the free-way with three 140 foot buildings (Figure 5.6)

A vertical wind speed profile was developed to simulate actual wind conditions in the project area. Experience has shown that with a qualitative analysis using smoke for a tracer, no differentiation can be made in flow characteristics for modest changes in approach profile. Thus, a single approach profile with $\alpha = 0.27$ was selected to represent all approaches. The approach wind profile used for the qualitative study of pedestrian winds is shown in Figure 5.7. In addition the wind tunnel

Figure 5.1 International Place Site and Surroundings



Figure 5.2 Site Configuration PRE - Pre-Construction Phase

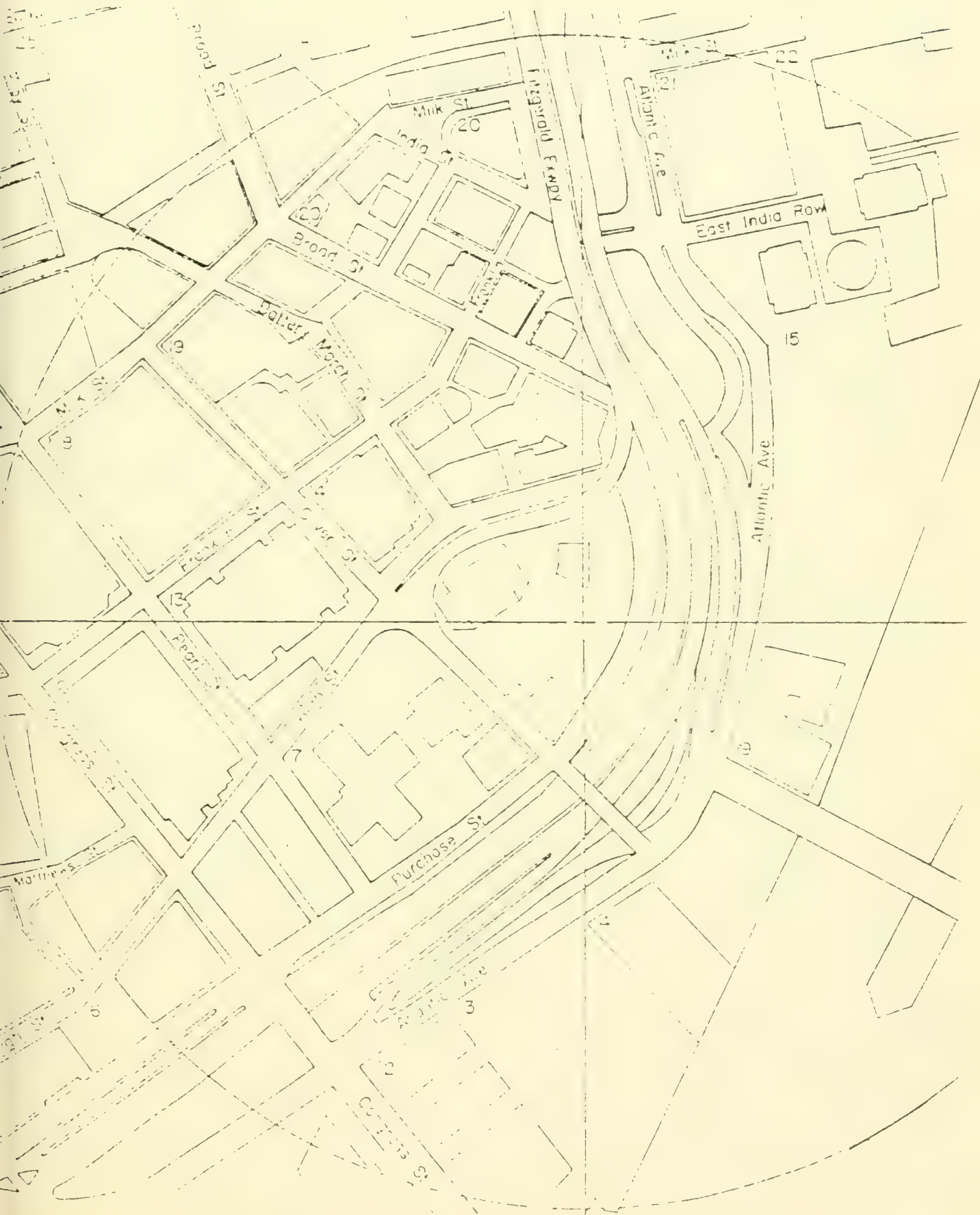


Figure 5.3 Site Configuration PH1 - South Tower and Lowrise

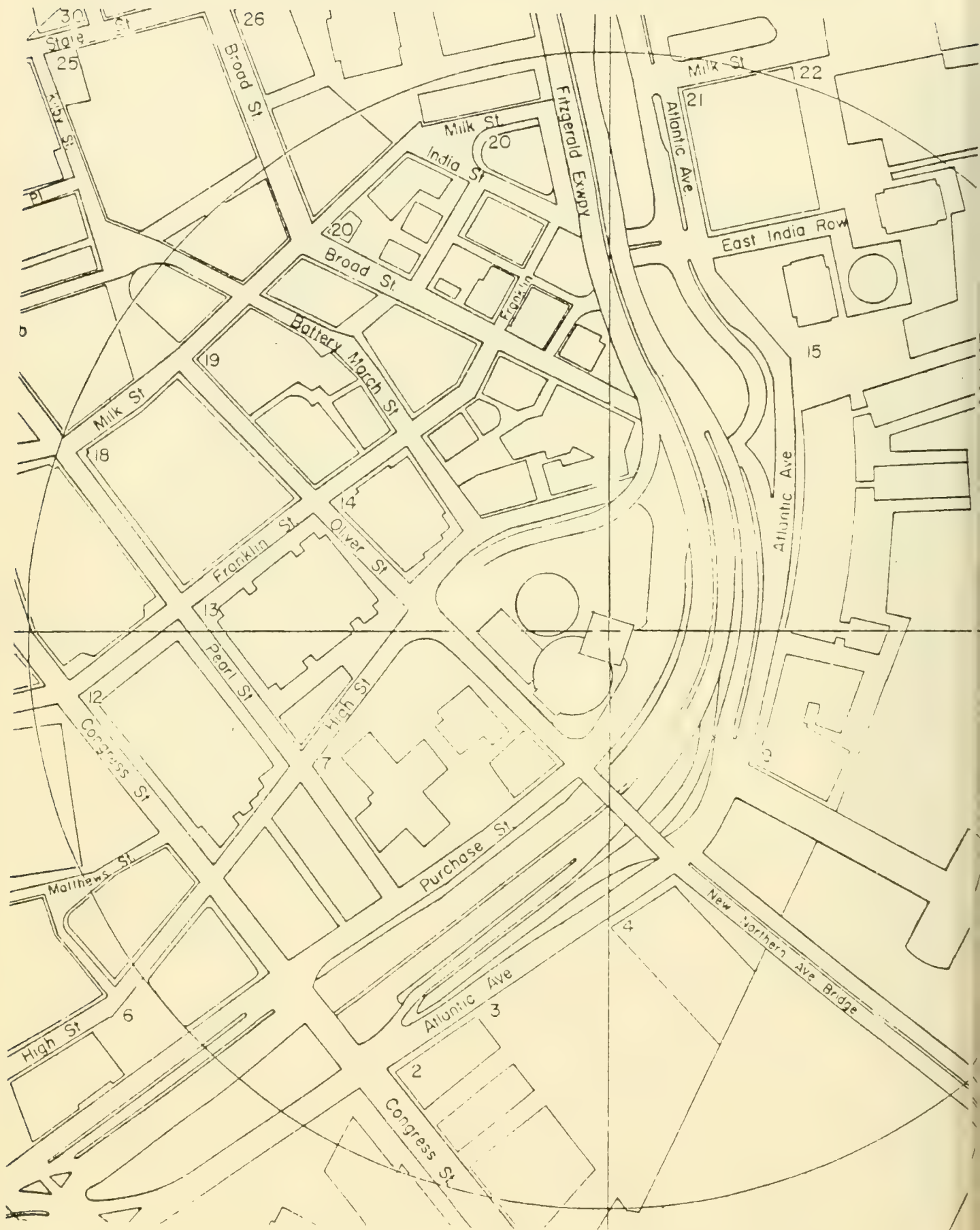


Figure 5.4 Site Configuration PH2 - Both Towers in Completed Project

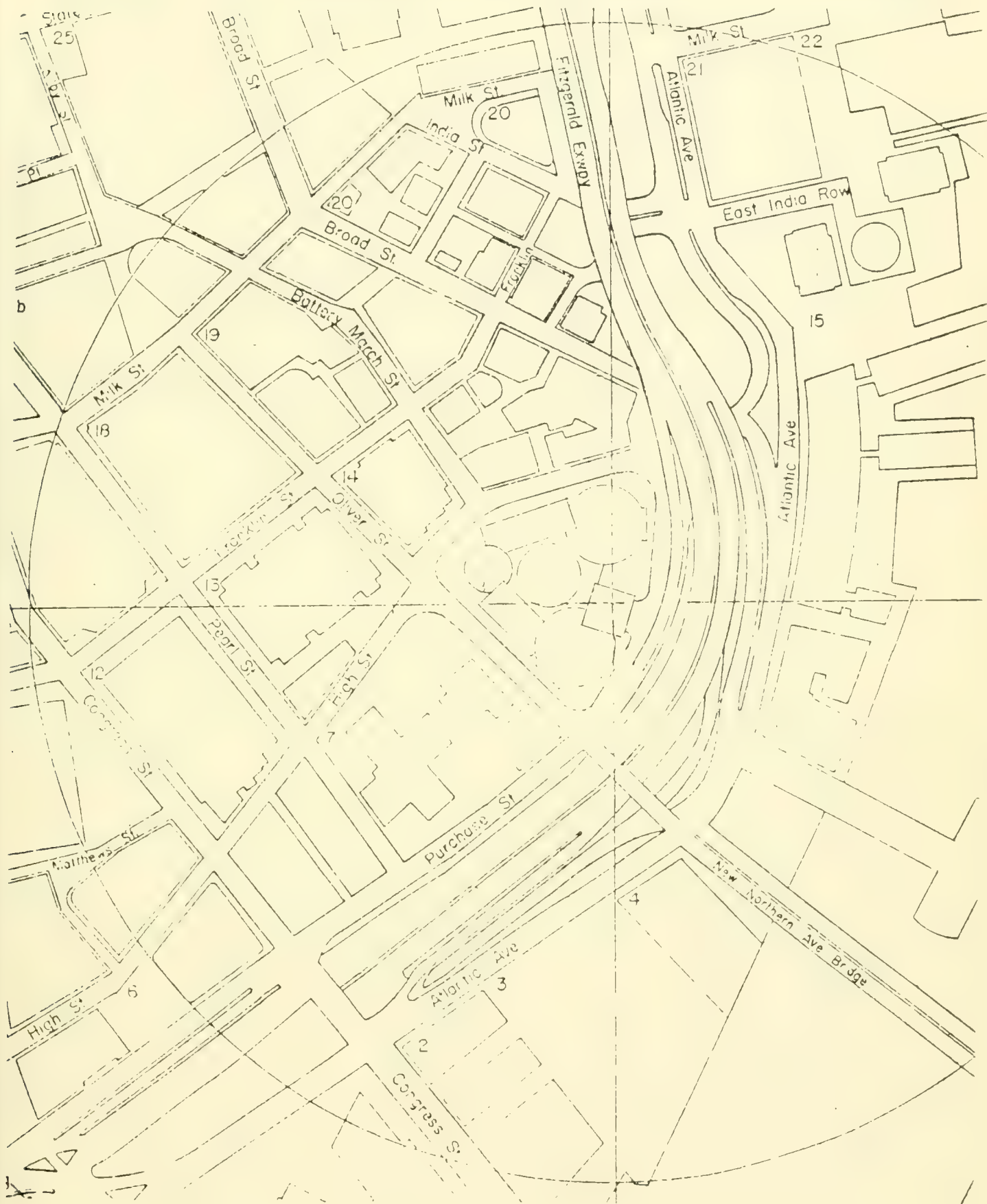


Figure 5.5 Site Configuration PH1F -
Configuration PH1 with Added Freeway Structures

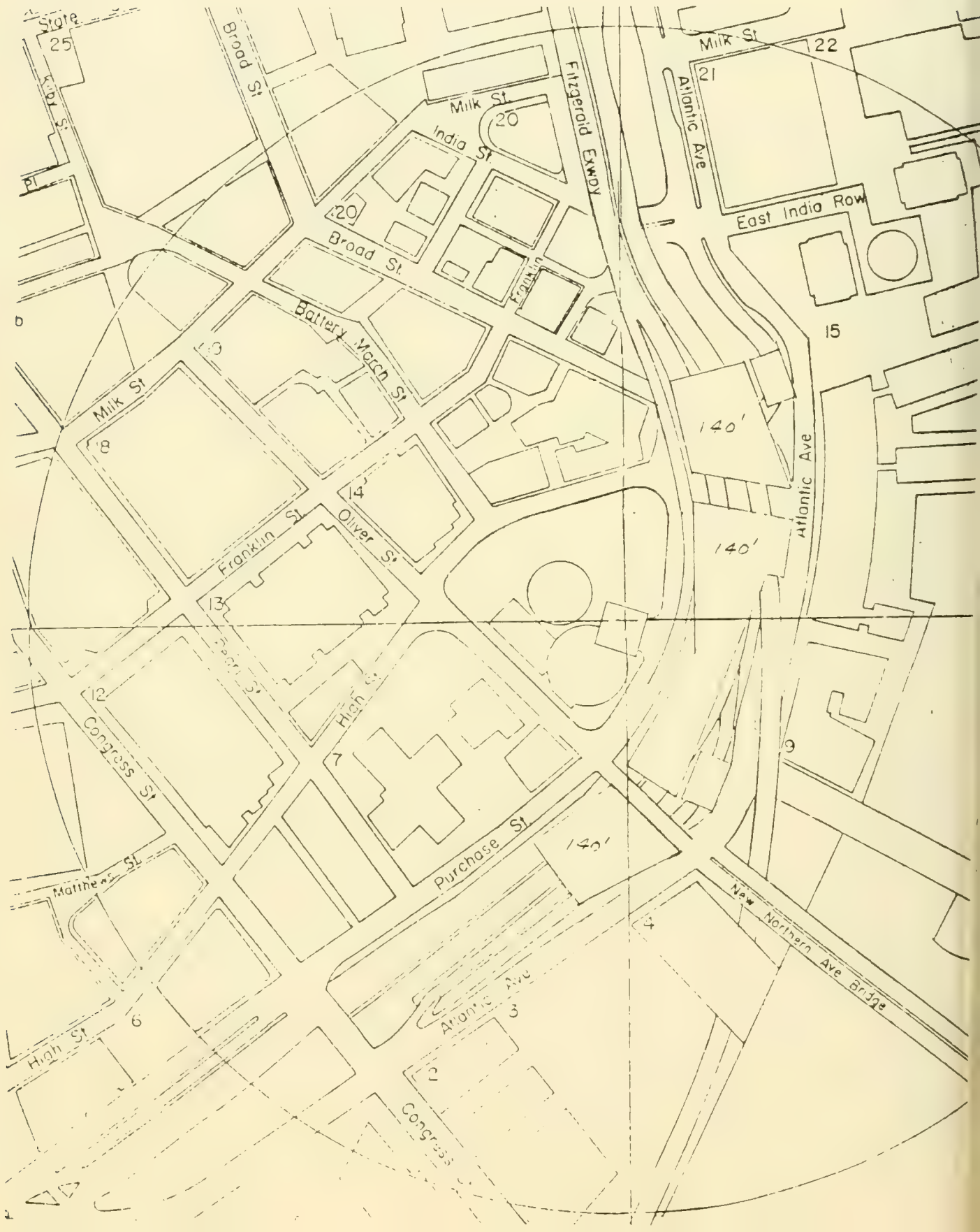


Figure 5.6 Site Configuration PH2F -
Configuration PH2 with Added Freeway Structures

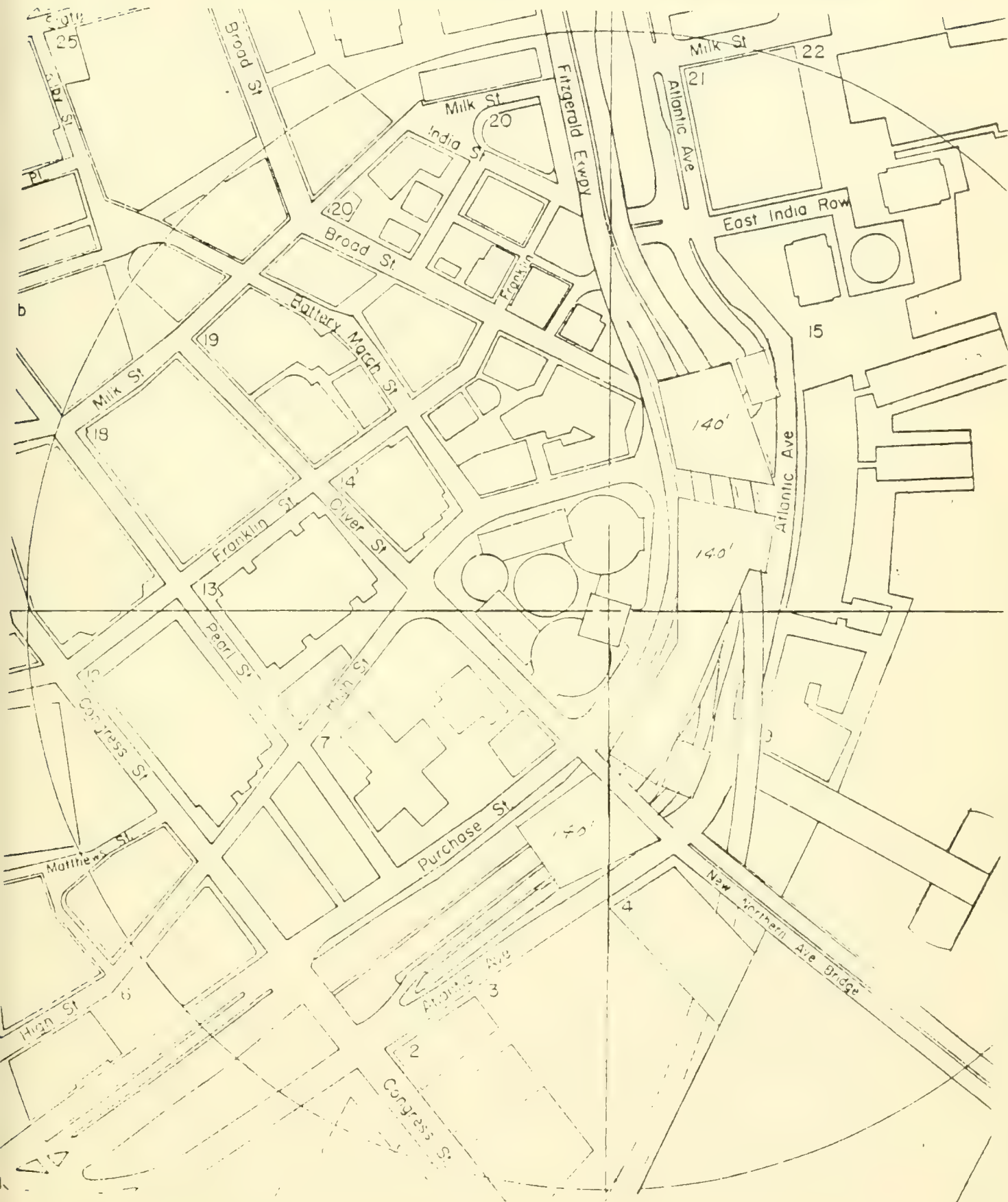
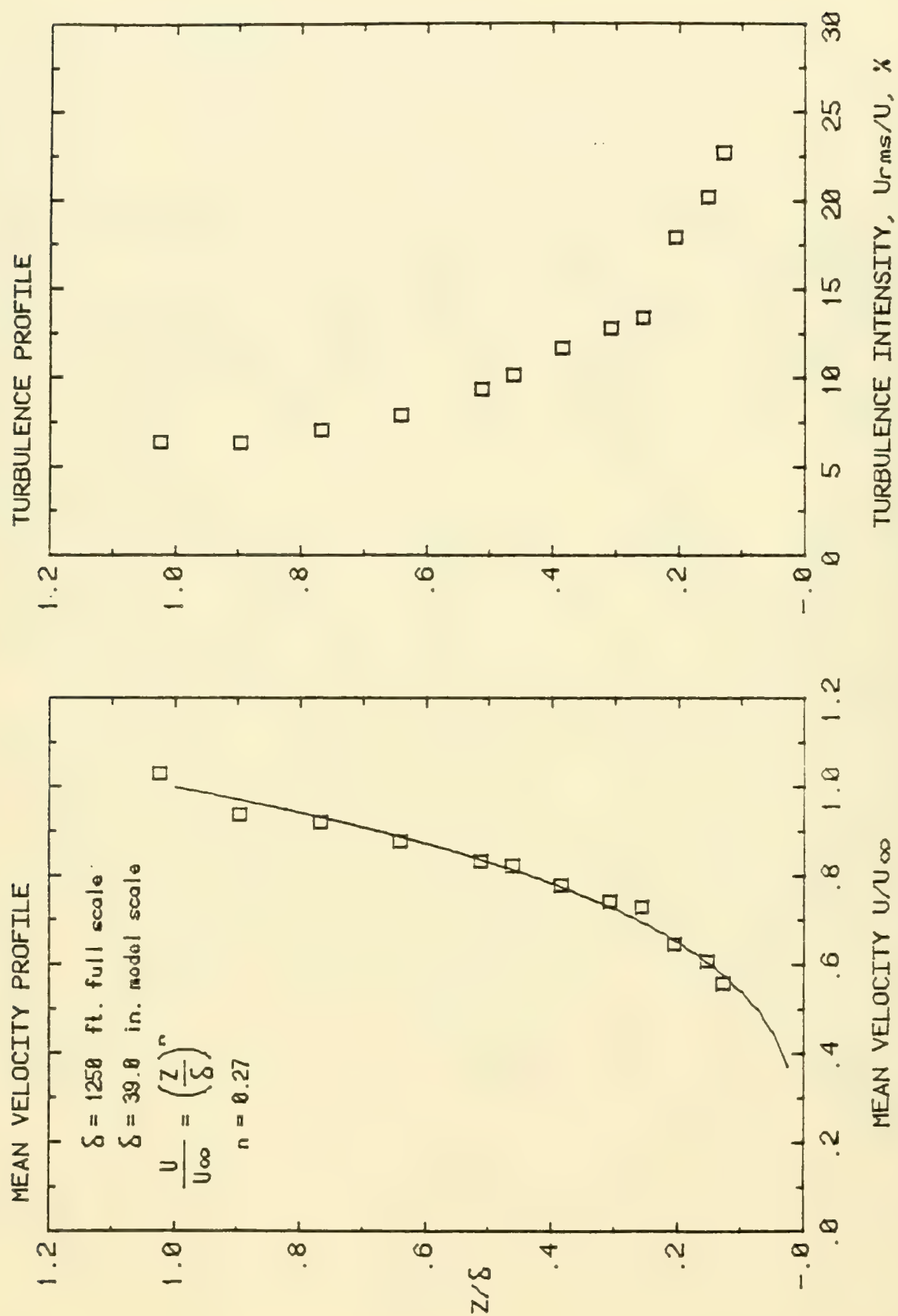


Figure 5.7 Approach Wind Profile Characteristics



provides the capability of rotating the model so that pedestrian level winds can be simulated and examined at different wind directions.

By performing the wind analysis at a number of wind directions, some of which are selected on the basis of observations just made at other wind directions, "hot spots" of high velocities were identified. An experienced practitioner can quickly cover a wide area, identifying hot spots or recording wind speed levels. A written record of the flow visualization was compiled to identify specific locations to be investigated in more detail in the quantitative study.

Examination of pedestrian winds did not concentrate solely on high velocity hot spots. Areas where low velocities are changed to moderate velocities for a number of wind directions may represent a significant deterioration in pedestrian environment. The reverse is also true. High traffic areas should be addressed even if hot spots are not evident, as modest changes in environment may change pedestrian traffic patterns. This is particularly true for pedestrian areas which were designed for long-duration activities.

In addition to defining wind speeds at ground level, smoke visualization provides an understanding of why a particular flow speed exists by examining the flow conditions upwind and above the surface. For example, high wind velocities at the corner of a building may be seen to be the result of wind flow down the windward face of the building causing wind to "converge" toward the surface at the corner.

With this procedure, a qualitative evaluation of local wind speed was obtained by classifying wind speeds into categories of high, moderate, low, and stagnant. A

moderate wind speed is best representative of the velocity in an open area away from any significant influence of structures. High wind speed is a velocity significantly faster than "moderate". High wind speeds may be observed at isolated spots rather than in large areas, but any high velocity "hot spot" in an area results in classifying the entire area as high velocity. Low velocity is lower than moderate wind speed, but not stagnant. Stagnant indicates little or no air motion in an area. Where an area was classified as high, maps were marked with the location of the high velocity "hot spots" within the area as well.

For the International Place project the general sensitivity testing for high velocity locations was undertaken out to a radius of 1500 feet from the site. In addition nineteen specific study areas were identified in advance by representatives of BRA and the Chiofaro Company during a working meeting. These are presented in Figure 5.8. Each area was examined by smoke flow for each of the eight compass points. For each wind direction the velocity in the different area was rated in one of the four wind speed categories described above. The five construction configurations as presented in Section 5.2 were examined. The results are presented in Table 5.1.

5.3. Results and Discussions

A number of locations which had high wind speeds, based on the definition provided in Section 5.2, were identified. These locations are shown in Figures 5.9a-e. No changes in high wind areas were observed beyond one block from the project site with changes in project configuration. It was evident from observation of smoke flow that significant influences from any of the model configurations did not extend beyond about one half block from the project

Figure 5.8 Location of Pedestrian Areas for Qualitative Evaluation

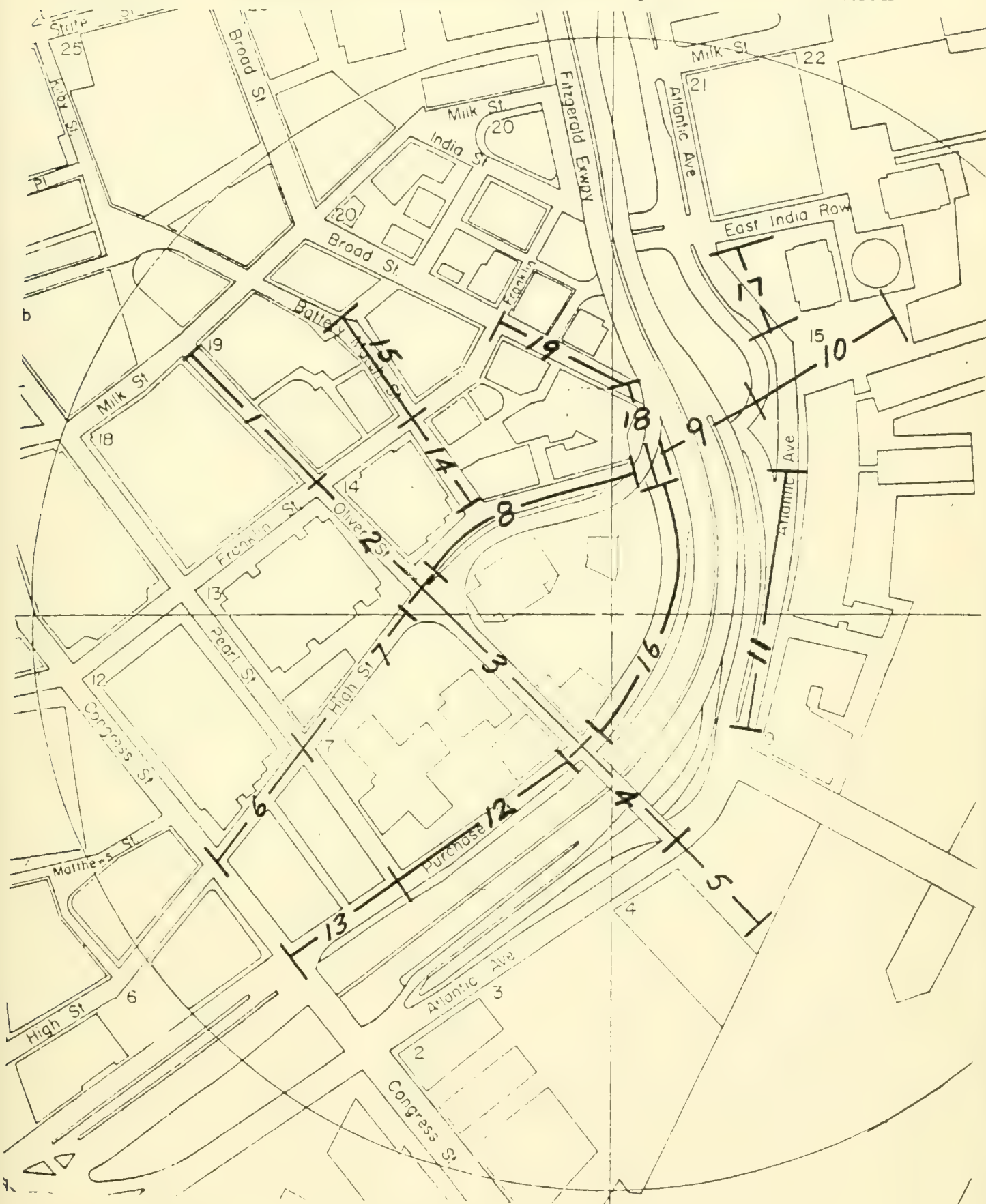


Table 5.1

Results of Flow Visualization Study

Number of Wind Directions with Specified Wind Speed											
Wind Speed						Wind Speed					
Area						Area					
No.	Conf.	High	Mod	Low	Stag	No.	Conf.	High	Mod	Low	Stag
1	PRE		4	4		6	PRE		5	3	
	PH1		2	5	1		PH1		5	3	
	PH2		3	5			PH2		5	3	
	PH1F		3	5			PH1F		5	3	
	PH2F		4	4			PH2F		5	3	
2	PRE	1	5	2		7	PRE		6	2	
	PH1	1	5	2			PH1		6	2	
	PH2		6	2			PH2		6	2	
	PH1F		6	2			PH1F		5	3	
	PH2F		6	2			PH2F		6	2	
3	PRE		4	4		8	PRE		6	2	
	PH1	4	3	1			PH1		4	4	
	PH2	4	4				PH2	2	4	2	
	PH1F	2	5	1			PH1F		4	4	
	PH2F	2	6				PH2F	1	4	3	
4	PRE		8			9	PRE		7	1	
	PH1		6	2			PH1		4	4	
	PH2		6	2			PH2		5	3	
	PH1F		5	3			PH1F		3	5	
	PH2F		5	3			PH2F		4	4	
5	PRE	2	3	3		10	PRE	5	3		
	PH1		3	5			PH1	5	3		
	PH2		4	4			PH2	5	3		
	PH1F		4	4			PH1F	5	2	1	
	PH2F		4	4			PH2F	5	2	1	

Table 5.1 (cont'd)

Results of Flow Visualization Study

Number of Wind Directions with Specified Wind Speed											
Wind Speed						Wind Speed					
Area						Area					
No.	Conf.	High	Mod	Low	Stag	No.	Conf.	High	Mod	Low	Stag
11	PRE	1	6	1		16	PRE		6	2	
	PH1		7	1			PH1	4	2	2	
	PH2		6	2			PH2	2	4	2	
	PH1F	2	6				PH1F	5	3		
	PH2F	1	6	1			PH2F	3	5	1	
12	PRE	1	4	3		17	PRE	1	6	1	
	PH1		5	3			PH1	1	6	1	
	PH2		5	3			PH2	1	6	1	
	PH1F		6	2			PH1F		8		
	PH2F		6	2			PH2F		8		
13	PRE		5	3		18	PRE		7	1	
	PH1		5	3			PH1		7	2	
	PH2		5	3			PH2	1	4	3	
	PH1F		5	3			PH1F	1	5	2	
	PH2F		5	3			PH2F	1	4	3	
14	PRE		7	1		19	PRE		4	4	
	PH1		7	1			PH1		2	6	
	PH2	1	5	2			PH2		1	7	
	PH1F		6	2			PH1F			8	
	PH2F	1	3	4			PH2F			8	
15	PRE		3	4	1						
	PH1		3	5							
	PH2		1	6	1						
	PH1F		2	6							
	PH2F		2	5	1						

Figure 9a High Velocity Areas for Configuration PRE



Figure 9b High Velocity Areas for Configuration PH1

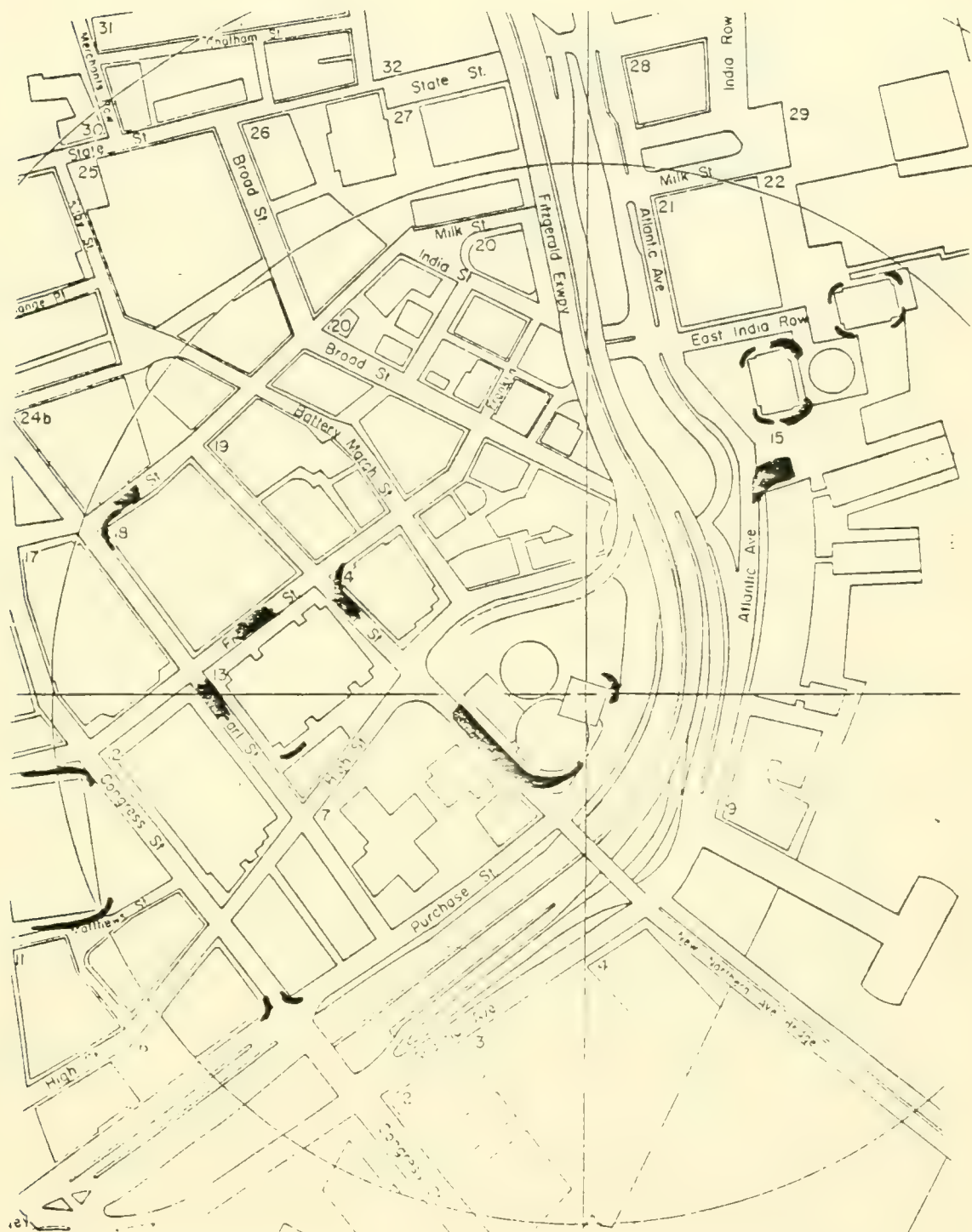


Figure 9c High Velocity Areas for Configuration PH2

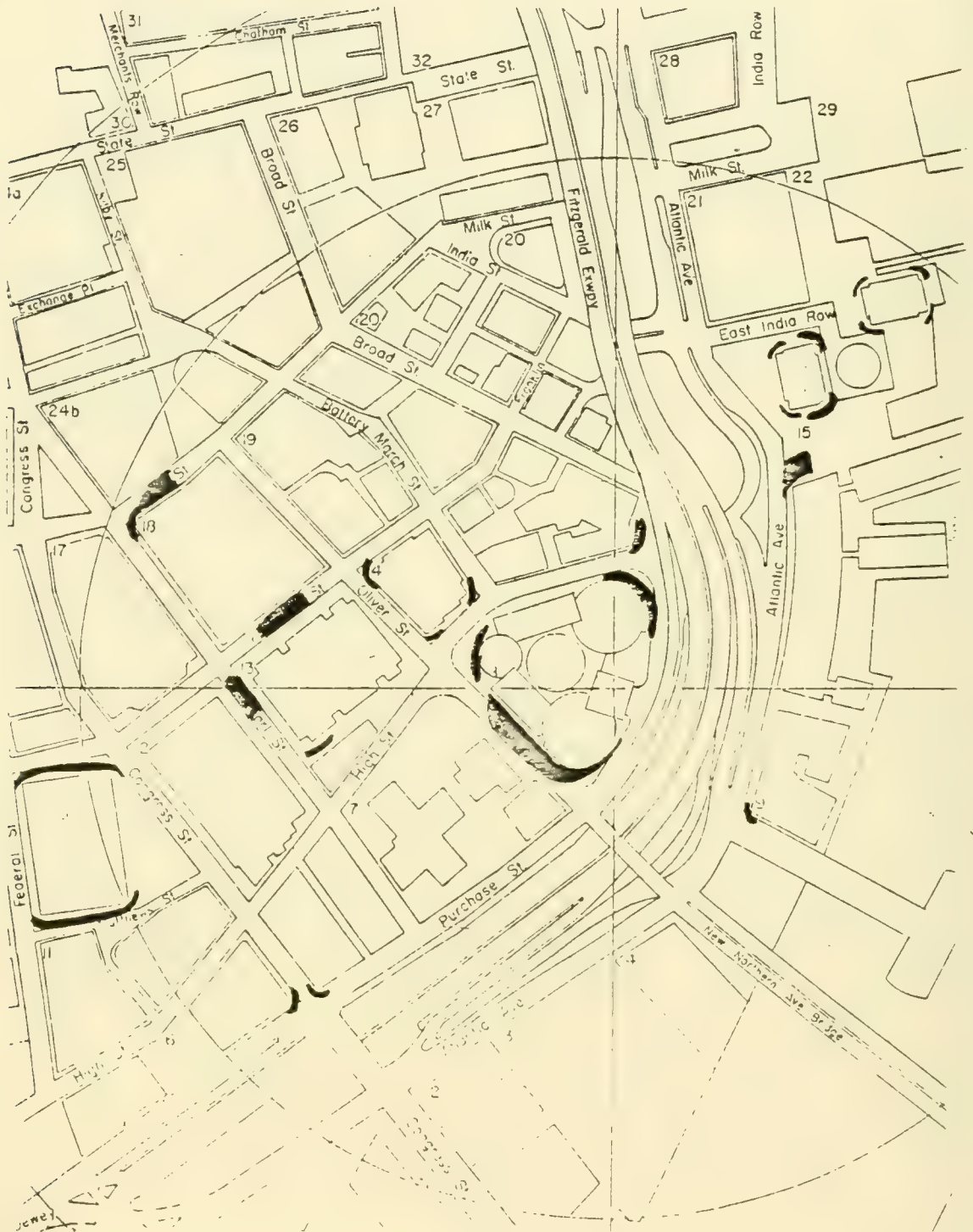


Figure 9d High Velocity Areas for Configuration PH1F

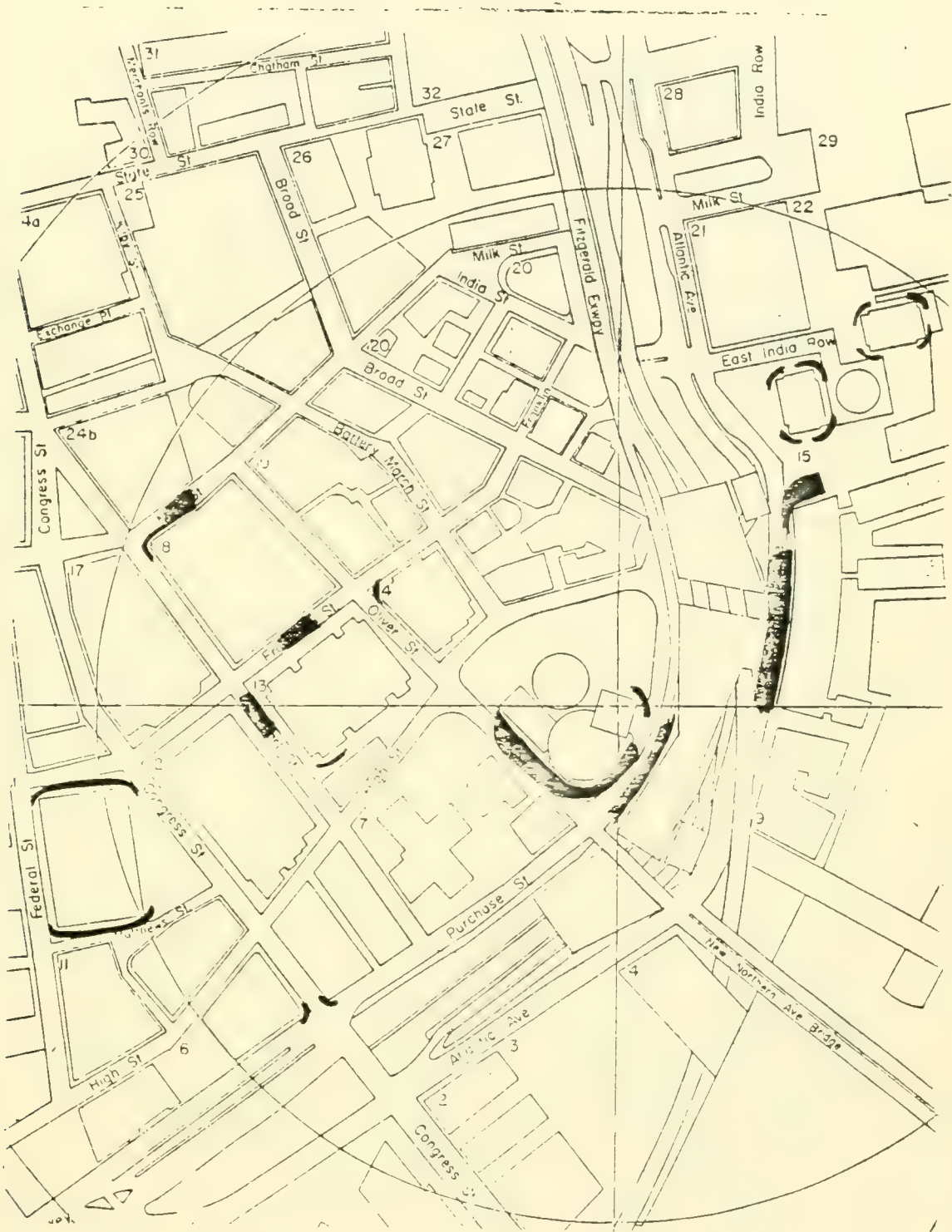
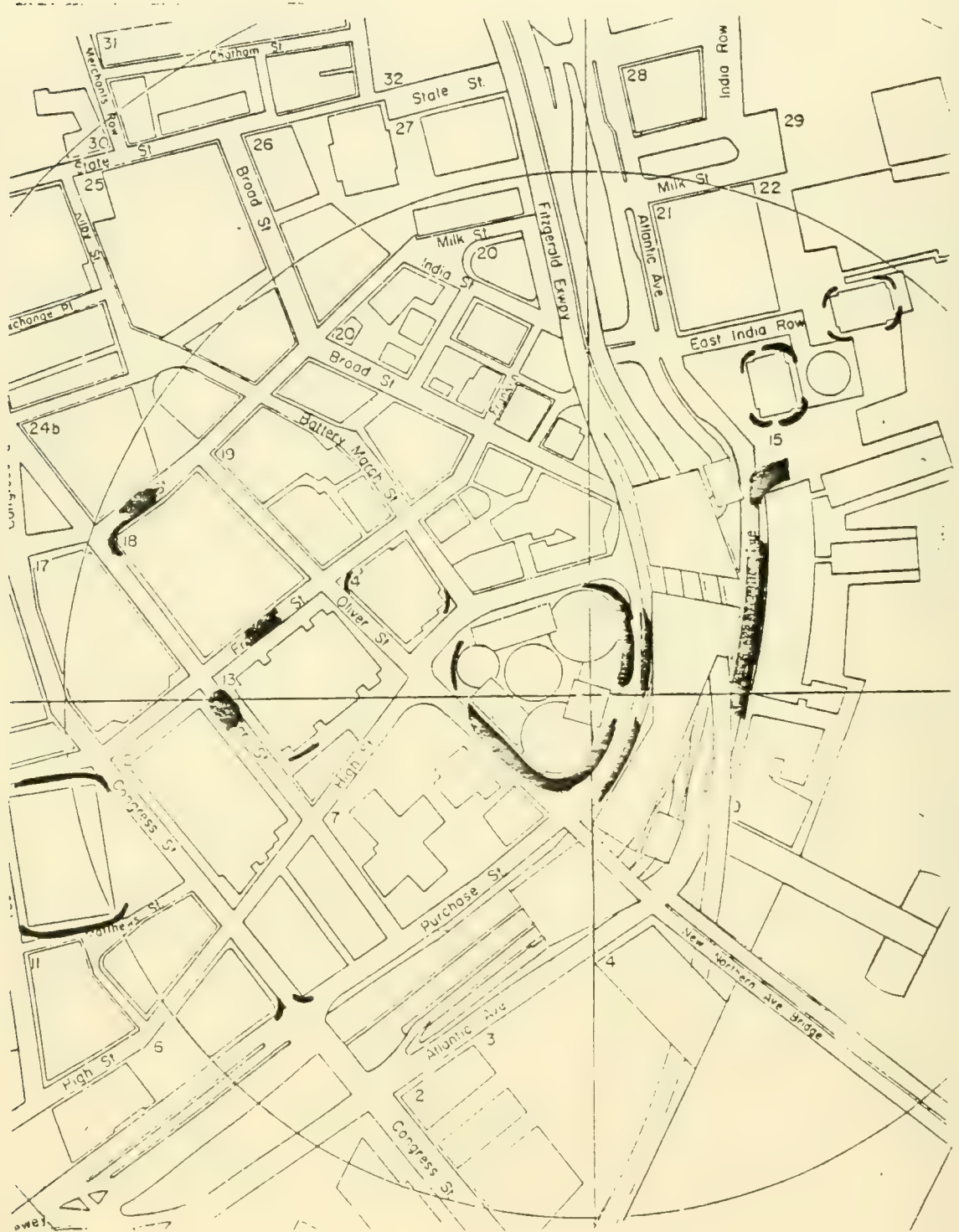


Figure 9e High Velocity Areas for Configuration PH2F



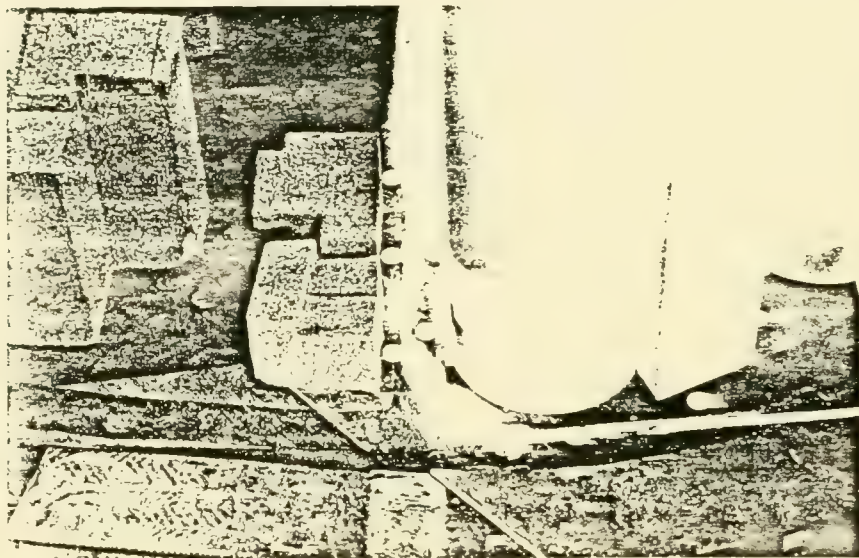
site, except directly downwind where some decreases in wind speed were observed at distances of one to two blocks. It is possible (and probable based on previous experience with other projects) that measurable decreases in wind speed might be found 500 to 1000 ft downwind of the project.

High wind speeds, due at least in part to the new development, were observed about the base of the International Place project. One of these areas is shown in Figure 5.10 for an east wind. High wind speeds were also observed at several locations considerably removed from the project site where the project had no influence on the wind flow. Two of these areas are shown in Figure 5.11 for an east wind. No qualitative differences could be identified between wind speeds in the three high wind areas.

In addition, data compiled in Table 5.1 for the nineteen specific areas lead to the following observations:

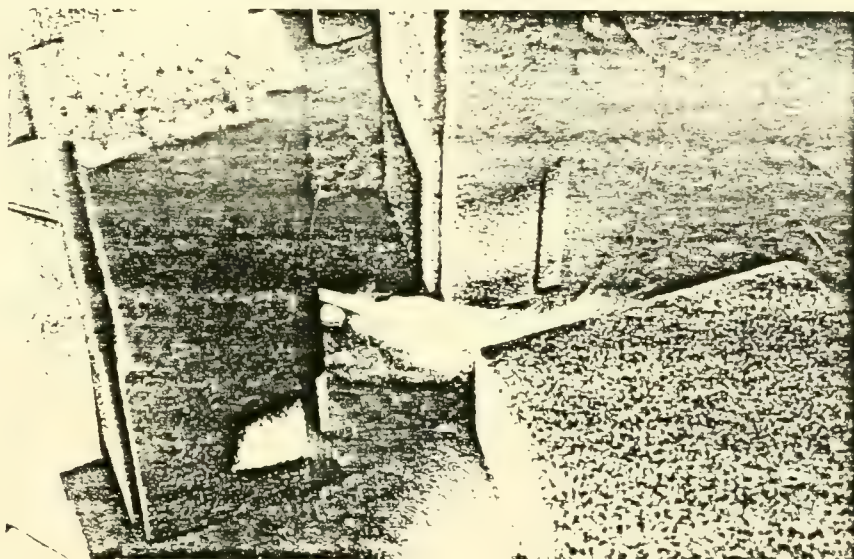
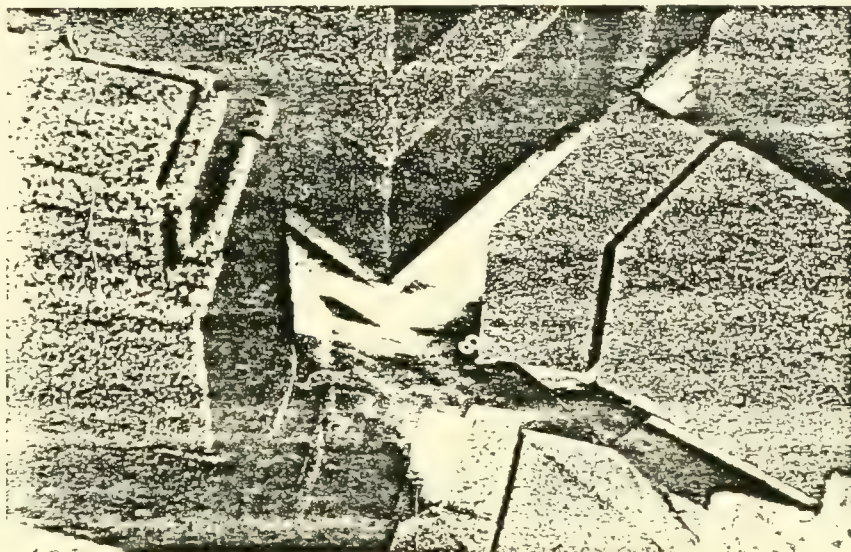
- Area 1. The PRE case was evenly divided between moderate and low winds with no high wind areas. The influence of the various project configurations was to slightly decrease, or leave unmodified the existing wind speeds.
- Area 2. The PRE case showed high winds for an easterly wind direction and moderate winds for most other directions. This is a result of the area's exposure to east winds and the shielding of surrounding buildings for other wind directions. The PH1 project did not change that environment. The other project configurations reduced the one high wind direction to moderate as a result of additional shielding, while leaving wind speeds at other directions qualitatively unchanged.

Figure 5.10 Flow Visualization of a High Wind Area
on the Project Site for an East Wind



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Figure 5.11 Flow Visualization of Two High-Wind Areas
Away from the Project Site for an East Wind



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Area 3. The PRE case was evenly divided between moderate and low winds with no high wind areas. Both the PH1 and PH2 cases increased the wind speeds with 4 of the 8 wind directions producing high winds (NE, E, SE, S). Tracing the source of the high winds demonstrated that the project towers deflect high velocity winds from upper levels to street level. Inclusion of PH1F and PH2F halved the number of wind directions with high winds. Their effect was to inhibit the full deflection of winds to sidewalk level for wind directions where the air rights development associated with the depressed artery were upstream. The shielding effect of air rights development is expected to increase if their heights increase since upper level winds would be less able to penetrate to street level.

Area 4. This area was not greatly affected by any adjacent structures in the PRE configuration. Addition of any of the other configurations decreased wind speeds in this area for wind directions where the project is upwind and blocking the approaching wind. Accelerated winds about the base of the International Place towers do not extend a sufficient distance from the tower to significantly increase winds in this area.

Area 5. Two wind directions showed high wind speeds in this area in the PRE configuration. The other wind directions split between moderate and low. The high winds were caused by winds deflected by an adjacent building to the south near Fort Point Channel. The 4 International Place configurations reduced the high winds by blocking wind flow into the area. A net benefit to this location appeared to occur as a result of the project.

Area 6. Winds at this location were split between moderate and low. No influence of any of the project configurations were detected.

Area 7. Winds in this area were predominantly moderate with low winds observed for a few wind directions. The presence of the various project configuration had little influence on winds in this area.

Area 8. Winds were primarily moderate in the PRE configuration. Addition of PH1 decreased the wind speeds. High speed winds deflected downward and away from International Place under the PH2 configuration did not extend far enough to impact this area. The presence of PH2 caused accelerated winds about the base of the project to be directed into this area. The high winds occurred for north and northeast winds where the site is exposed to an open approach and where orientation of the project tends to deflect higher elevation winds down to the surface. The winds in this area tended to be high near the west entrance to the project site near the intersection of Oliver and High Streets and near the base of the north tower.

Area 9. Winds were predominantly moderate in the PRE configuration. No structure in the PRE configurations had a major impact on this area. The presence of the PH1 and PH2 configurations blocked approach winds for some wind directions, thus decreasing wind speeds somewhat in this area. This area fell between two buildings in the PH1F and PH2F configurations and was thus dominated primarily by these structures. These

configurations did not cause a major change in velocity categories even though they caused changes in wind flow patterns in this area (all winds were east/west between the buildings).

Area 10. This area had high winds for a number of wind directions due to the presence of two tall adjacent buildings (Harbor Towers). These winds were not affected by the PH1 or PH2 configurations as International Place was not found to influence existing wind levels out to this distance. The PH1F or PH2F configurations decreased these winds slightly as the air rights development associated with the depressed artery blocked winds from the southwest.

Area 11. Winds were predominantly moderate in the PRE configuration. Addition of the PH1 or PH2 configurations decreased wind speeds by blocking approaching winds. Addition of PH1F or PH2F increased wind speeds to match or slightly exceed the PRE level. Wind channeling between the freeway buildings and the building east of area 11 was the cause of the increased wind speeds with PH1F or PH2F.

Areas 12 and 13. Both areas had similar winds divided primarily between moderate and low for the PRE configuration; except for one high at Location 12. Location 12 experienced some changes in wind characteristics with introduction of the various building configurations. The only significant modification was to decrease the one high wind to moderate. Location 13 was too far from the construction site to experience significant modification to its wind environment.

- Area 14. Wind speeds were predominately moderate in the PRE configuration. PH1 did not significantly change that environment. PH2 brought higher velocity winds to area 8 and, at the same time, brought an increase at one wind direction and decrease at another wind direction to area 14. The high winds generated by PH2 were at the intersection with area 8 (High Street and Battery March Street) across the street from the PH2 addition. Configurations PH1F and PH2F provided decreases in wind speed over the corresponding PH1 or PH2 case due to additional shielding by the air rights development associated with the depressed artery.
- Area 15. Wind classifications were split between moderate and low in the PRE configuration. All built configurations provided decreases in wind speeds, primarily by blocking wind for one or two wind directions.
- Area 16. Winds were mostly moderate in the PRE configuration. No structures nearby were sufficiently large to significantly modify the wind field. Addition of PH1 and PH2 increased winds in this area by deflecting high velocity wind from well above the surface down to ground level. This occurred primarily for winds with an easterly component. The addition of PH1F and PH2F did not improve the wind environment. Channeling of winds between the new structures tended to increase wind speeds while the height of the freeway structure tended to keep winds deflected from the towers from penetrating to the ground with strength; the trade-off left the winds high in this region.

Area 17. Winds were predominately moderate with local areas adjacent to a tall tower (west tower of Harbor Towers) having high wind. PH1 and PH2 configurations did not change that environment. The accelerated winds about the towers could not reach this far. PH1F and PH2F provided a small modification to the local wind speeds.

Area 18. Winds were mostly moderate in the PRE configuration. PH1 induced a decrease in winds by blocking southerly winds. PH2 provided both increases and decreases by deflecting wind into this area for one wind direction and blocking winds for some other wind directions. PH1F and PH2F changed wind flow directions locally, but did not change the wind speed levels noticeably.

Area 19. Winds in the PRE configuration were split between moderate and low in this portion of the Broad Street Historic District. The addition of all other configurations decreased wind speeds by blocking approach winds.

Flow visualization showed clearly that the International Place building site is exposed to winds with essentially unobstructed paths from the north to north-northeast and from the south-southwest along the adjacent freeway corridor. In addition, the building is subject to an open exposure with only a line of low buildings upwind for wind directions from east-northeast to south. The building site is thus more exposed to winds than most of the tall buildings in the downtown area. Smoke flow confirmed these observations. Other tall buildings in the area which have open exposure to wind, for example, the two towers (Harbor Towers) northeast of

the site across the freeway, also showed high wind velocities about their bases which appeared to be similar in magnitude to velocities about the International Place project site.

Smoke visualization showed that the concentration of buildings from the southwest to north-northwest of the project site significantly decreased the strength of winds approaching the site. These wind directions contain the most frequent winds.

The results presented in Table 5.1, along with the other flow visualization results discussed above, demonstrate that significant changes in pedestrian wind speeds as a result of the International Place development are localized on the three streets directly adjacent to the project site. The velocity increases cover the full width of Oliver Street between Purchase and High Streets. On Purchase Street from Oliver to High Street, and on High Street from Oliver to Purchase, the velocities were greatest on the half street width nearest to the project site, with lesser increases on the half street width further from the project site.

The flow visualization study was not specifically designed to address air pollution concerns. However, some conclusions can be drawn relative to concern that the project might block natural wind flow into or out of the downtown area thereby increasing pollution levels. The flow visualization techniques demonstrate that the International Place structures will bring air from higher levels down to the surface on the windward side and pull surface winds up to higher levels on the lee side of the building. Thus, the buildings act like large stirring rods mixing polluted surface air into the upper levels of the atmospheric boundary layer where winds could disperse

the pollutants. The slight decrease in wind speeds observed at a distance downwind of the project can be expected to decrease slightly the local pollution dispersal action in those areas. It is probable that the strong mixing action of the building increasing dispersion will outweigh the small decrease downwind.

5.5. Suggested Study Locations of the Quantitative Analysis

On the basis of data and the analysis presented above, pedestrian level wind locations were recommended for the subsequent quantitative evaluation. Figure 5.12 shows the locations chosen. These were selected to define the existing wind environment at streets adjacent to the project site and areas out to one block away from the site under the PRE project configuration. In addition, a number of recommended high, moderate, and low velocity locations more than one block from the site were chosen. For the PH2 project configuration, the same locations were selected to define changes to the wind environment in the study area as a result of the proposed project.

Of the four International Place project configurations studied in the qualitative tests, two were selected, in addition to the preconstruction configuration (PRE), for further study in the Quantitative Analysis. The PH1 and PH2 configurations were chosen since they added high velocity areas to the wind environment, while the primary effects of PH1F and PH2F were to decrease winds about the project site, except for minor increases noted in one area.

Figure 5.12 Proposed Locations for Quantitative Wind Analysis



6. QUANTITATIVE ANALYSIS

6.1 Introduction

The quantitative analysis involved examining pedestrian level wind velocities at receptor locations about the project selected based upon the previous qualitative analysis results. Numerical analysis of mean wind speeds and effective gust velocities for the pre-construction, Phase I and Phase II configurations of International Place has been undertaken. Statistical representations of pedestrian level wind velocities were obtained at approximately 50 receptor locations. The receptor site locations are numbered and labeled in Figures 6.1a-c. The numbers of test sites chosen, by site configuration, are as follows:

- PRE - Preconstruction configuration, 47 locations plus a theoretical "open-country" site.
- PH1 - Phase 1 (south) tower and a portion of the enclosed courtyard, 50 locations.
- PH2 - Complete project including south tower, north tower and lowrise structure, 47 locations.

Pedestrian velocity measurements were made in the same boundary layer wind tunnel used for the flow visualization study. Three approach boundary layers were established to represent the three different upstream approach roughness categories typical of Boston. The target boundary layers (defined as "A", "B", and "C"), and their azimuthal ranges, are given in Section 4.2. Measurements of the boundary layer characteristics are also described in Section 4.2 showing that the target approach boundary layers were achieved. A more detailed description of the study approach for the Quantitative Analysis is presented in Appendix A.

Figure 6.1a Pedestrian Velocity Measurement Locations
for Configuration PRE



International
Place
at Fort Hill

HMM Associates
Concord, MA

Figure 6.1b Pedestrian Velocity Measurement Locations
for Configuration PH1



International
Place
at Fort Hill

HMM Associates
Concord, MA

Figure 6.1c Pedestrian Velocity Measurement Locations
for Configuration PH2



International
Place
at Fort Hill

HMM Associates
Concord, MA

Mean and root-mean-square (RMS) wind velocities were measured at each pedestrian location in each of the three design configurations for 16 wind directions. These data represent 2320 individual measurements. Non-dimensional wind velocities were utilized by dividing by the wind tunnel reference velocity (V_{inf}) at 900 ft. This reference velocity was at gradient level for boundary layer "A", (see Section 4.1) and somewhat below gradient for boundary layers "B" and "C". Mean and effective gust (mean plus 1.5 RMS) velocities derived from the wind tunnel testing and the subsequent statistical analysis are outlined in Tables 6.1 (mean wind speeds) and 6.2 (effective gust velocities).

The results of the quantitative wind tunnel modeling at these receptor sites have been recorded and compared to the ambient wind environment in Boston, to existing wind levels at other existing sites in the financial district, to the informal BRA wind design guidance level (effective gust velocity exceeded 1% of the time >31 mph), and to the Melbourne criteria that are outlined in Figure 3.1.

6.2 Existing Wind Speeds

Existing mean wind speeds, as outlined in Table 6.1, vary greatly in the area within 1500' of the Fort Hill site. Two of the 47 sites have existing wind speeds above the "dangerous" threshold suggested in the Melbourne Criteria (see Figure 3.1). These are site #32, adjacent to the Hook Lobster building, with an observed mean wind speed of 34 mph, and site #24, adjacent to Harbor Towers, with an observed mean wind speed of 28 mph.

TABLE 6.1

MEAN VELOCITIES (mph) EXCEEDED ONE PERCENT
OF THE TIME

<u>Location</u>	<u>Configuration</u>			<u>Location</u>	<u>Configuration</u>		
	<u>PRE</u>	<u>PH1</u>	<u>PH2</u>		<u>PRE</u>	<u>PH1</u>	<u>PH2</u>
1	20	19	18	26	22	25	25
2	25	24	23	27	20	23	22
3	16	16	16	28	19	13	18
4	16	16	20	29	20	22	24
5	22	17	19	30	14	14	16
6	16	16	17	31	22	20	22
7	20	16	14	32	34	33	37
8	11	17	16	33	25	22	22
9	14	16	16	34	25	21	21
10	16	14	16	35	12	14	13
11	17	17	17	36	9	21	16
12	20	17	15	37	12	22	26
13	16	16	15	38	13	20	24
14	13	15	16	39	14	17	17
15	17	18	20	40	9	25	21
16	13	10	13	41	14	22	23
17	15	16	15	42	13	14	14
18	12	20	23	43	9	16	17
19	10	17	17	44	12	18	23
20	9	12	19	45	13	22	20
21	12	17	16	46	14	21	21
22	14	13	14	47	14	26	21
23	15	15	15	48	22*	16**	
24	28	29	29	49		17**	
25	27	26	27	50		21**	

* This velocity for PRE configuration only corresponds to a calculated open-country velocity with $V/V = 0.45$ -- see text.

** Locations which existed only for configuration PH1.

TABLE 6.2

GUST (MEAN + 1.5 RMS) VELOCITIES (mph) EXCEEDED
ONE PERCENT OF THE TIME

<u>Location</u>	<u>Configuration</u>			<u>Location</u>	<u>Configuration</u>		
	<u>PRE</u>	<u>PH1</u>	<u>PH2</u>		<u>PRE</u>	<u>PH1</u>	<u>PH2</u>
1	30	28	27	26	31	34	35
2	36	35	34	27	29	30	30
3	26	27	26	28	27	21	27
4	25	26	29	29	28	31	34
5	30	24	26	30	22	21	24
6	24	24	24	31	28	27	29
7	28	23	21	32	49	47	53
8	18	26	24	33	33	31	31
9	21	24	24	34	36	32	32
10	24	20	23	35	18	21	20
11	27	24	26	36	14	30	25
12	27	24	22	37	19	31	34
13	24	23	23	38	21	27	35
14	22	23	24	39	22	24	25
15	25	24	27	40	15	34	30
16	21	16	29	41	21	30	31
17	22	22	22	42	20	23	21
18	19	27	30	43	15	24	25
19	15	23	25	44	19	28	31
20	14	18	26	45	21	32	31
21	18	25	23	46	21	33	30
22	22	20	22	47	24	37	30
23	25	25	25	48	30*	25**	
24	37	37	38	49		27**	
25	36	36	38	50		33**	

* This velocity for PRE configuration only corresponds to a calculated open-country velocity with $V/V = 0.45$, $V_{rms}/V = 0.11$ -- see text.

** Locations which existed only for configuration PH1.

Twelve of the 47 receptor locations (26%) are located in areas rated as "uncomfortable but acceptable for walking". These locations include sites #1, #2, #7, and #12 at distances more than a block west or south of the project site at various locations in the financial district; a string of sites including #25, #26, #27, #29, #33, and #34 along the east edge of Atlantic Avenue from Harbor Towers to the Hook Lobster building; and site #31 across Fort Point Channel. Eight more sites were locations at which walking would be judged to be comfortable (with mean wind speeds between 16-19 mph no more than 1% of the time). These sites included hot wire locations #3, #4, #6, #10, #11, #13, and #15 in the financial district south and west of the site, and receptor #19 on High Street, adjacent to the project site.

The remaining 27 sites included locations with observed mean wind speeds of less than 16 mph. According to the Melbourne Criteria these locations can accommodate pedestrians for either stationary short term exposures (14 sites), or for long term stationary exposures (17 sites). The sites with these more pleasant wind speeds include sites #8, #9, #14, #16 and #36-40 along the Oliver Street corridor; sites #17-22 in the Custom House Historic District just west of the project site; and sites #41-47 on the project site and its periphery.

Table 6.2 shows existing effective gust velocities at the same set of hot wire receptor locations. The patterns of high versus low wind speeds are similar to those for mean wind speeds. The BRA criterion calling for effective gust velocities ≤ 31 mph is exceeded at six of the 47 receptor locations. The six locations are the six that also had the highest mean wind speeds. They are location

#2, at the corner of Franklin and Congress, locations #24 and #25 at Harbor Towers, and locations #32-34 along Atlantic Avenue. The observed gust value of 49 mph at the Hook Lobster building is a particularly high value.

Location 48 in the PRE configuration was added as a theoretical site representing open terrain. It had a mean velocity of 22 mph, which is only 5 mph below the Melbourne "potentially dangerous" criterion. An effective gust velocity of 30 mph, which is only 1 mph below the BRA acceptance criterion, was also calculated at this location. At location 31, in an open area where some shielding from the mass of the city can be felt, similar results were measured. A mean velocity of 22 mph was found for the PRE configuration, and an effective gust velocity of 28 mph was measured. These two locations demonstrate the naturally windy environment in the City of Boston. They also show that moderate increases of the mean velocity, and only small increases in effective gust levels, may cause an exceedance of either the Melbourne criterion or the BRA informal design guidance criterion.

In total the observed existing wind speed data indicate both a great deal of variability in wind speeds in the area within 1/4 mile of the project, and some reasonably high ambient wind levels. These high levels are evidenced both by exceedances of the BRA criterion at 13% of the sites, and by indications of two "potentially dangerous" locations and 12 "uncomfortable but acceptable" locations according to the Melbourne Criteria.

6.3 Wind Levels with the Project

By reviewing the mean wind velocities of Table 6.1 and comparing them to the Melbourne Criteria (Figure 3.1) the data in Table 6.3 were derived. This table provides an

TABLE 6.3

COMPARISON OF OBSERVED MEAN WIND SPEED
TO THE
MELBOURNE CRITERIA
AT 1% FREQUENCY OF OCCURRENCE

	PRE Con-	PH1 Con-	PH2 Con-
	figuration	figuration	figuration
1. Potentially Dangerous Wind Speed (>27 mph)	2	2	2
2. Uncomfortable but Acceptable for Walking (20-27 mph)	12	18	19
3. Comfortable for Walking (16-19 mph)	8	20	16
4. Acceptable for Short Term Stationary Exposure (13-15 mph)	14	5	10
5. Acceptable for Long Term Stationary Exposure (<13 mph)	11	2	-

overview of the nature of changes in pedestrian level wind environment. From the table it is apparent that there is no change in the number or locations deemed potentially dangerous by the Melbourne Criteria. Sites #24 (at Harbor Towers) and #32 (Hook Lobster), which were observed to have dangerous wind levels at present, continue to have comparable wind speeds in both the PH1 and PH2 development stages. From these data it is reasonable to conclude that no new hazards are created by the project, nor are the existing hazards ameliorated with the introduction of International Place.

Table 6.3 shows that the number of locations rated as "uncomfortable but acceptable for walking" increases from 12, at present, to 18, with the PH1 configuration, and to 19 with the completed project of PH2. The net increase of 7 locations with higher, uncomfortable wind speeds is due, almost entirely, to changes in winds on or near the periphery of the development site. Sites #37, #38, #40, #41, #44, #45, #46 and #47 are eight sites in this category. Each is on Oliver, Purchase, or High Street, or immediately adjacent to the International Place site.

The number of sites rated as "comfortable for walking" by the Melbourne Criteria increases from 8, in the existing case, to 20, with the PH1 configuration, then decreases back to 16 with the completion of PH2. Those sites that achieve the "comfortable for walking" rating by virtue of increased wind speeds are sites #8, #9, #14, #19, #20, #21, #36, #39 and #43. This is the set of receptor locations in close proximity to the site boundaries, but at a slightly greater distance than the previous set of sites rated as uncomfortable. Each of these sites is also on Purchase, High or Oliver Street.

The number of sites rated as acceptable for short term or long term stationary exposures drops from 25, in the

existing case, to 10 with the development of International Place. The sites that have lost these ratings as being acceptable for stationary exposures are the same sites, at the periphery of the project, that have increased in Melbourne Criteria ratings to uncomfortable or comfortable for walking.

The changes in mean wind speed patterns can be confirmed by comparing the effective gust velocities listed in Table 6.2 to the BRA design criterion limiting effective gust velocities to 31 mph. A review of the table indicates that six sites have effective gust velocities greater than 31 mph without International Place; the number of sites increases to 11 with the completion of PH1 and decreases to 9 with the completion of PH2. The nine sites are:

Site #32 at Hook Lobster. With an effective gust velocity of 53 mph this is by far the windiest of the test sites. Effective gust velocities are high with or without International Place. The wind tunnel tests indicate small reductions with the PH1 configuration, and small increases with the PH2 configuration. Due to both the existing wind levels and its distance from the development site (i.e., across the Central Artery and Atlantic Avenue) it appears that mitigating measures must take place at the receptor site, rather than at the development site.

Sites #24 and 25 at Harbor Towers. This pair of sites at Harbor Towers shows effective gust velocities of 38 mph with PH2. These are increases of 1 and 2 mph, respectively, from the existing case. This pair of sites, like receptor #32 at Hook Lobster, is well

removed from International Place, and affected minimally by its design. On-site changes at Harbor Towers appear to be the most practical means for reducing wind speeds at these locations.

Site #2 North Corner of the First National Bank. Predicted effective gust velocities at this location drop from 36 mph, with the PRE configuration, to 35 mph with PH1, and finally to 34 mph with PH2. This shows that, in a small way, the introduction of International Place will shield portions of the financial district from northeast winds across the harbor.

Site #26 and #29. At receptor locations 26 and 29 effective gust velocities increase from being equal to, or just below, the 31 mph criterion during the PRE configuration to levels at, or slightly above this criterion during the PH1 and PH2 configurations. These increases to levels equal to or greater than the BRA design guidance criterion are attributed to the proposed Rowes Wharf development, which was included in the International Place build configurations, but not in the no-build configuration. This conclusion is corroborated by the data in Figure IV-26, of the Rowes Wharf Development Final Environmental Impact Report, July 1984.

Site #34 Pedestrian Bridge across the Central Artery. At site #34 effective gust velocities decrease from 36 mph, in the existing case, to 32 mph in either the PH1 or PH2 configuration. The 10% decrease in winds is attributable to the shielding from northwest winds

provided by the south tower. The reduction nearly pushes the site within the BRA criterion.

Sites #37 and #38 Southeast Corner of International Place. Sites 37 and 38, at the southeast corner of International Place development (i.e., the south tower and entrance), experience increases in effective gust velocities from 19 and 21 mph, with the PRE configuration, to 34 and 35 mph with the completion of PH2. These relatively large increases are a direct result of the introduction of the new building elements along Oliver Street. The increases result from vertical deflection of winds off the south-facing facades, and from channeling of winds along the east-west axis of Oliver Street.

6.4 Conclusions

Boston is an extremely windy city. Effective gust velocities exceeded one percent of the time, even in open areas not influenced by adjacent high-rise structures (such as locations similar to Piers 1, 2, 3, and 4 and Logan Airport), are 30 mph. Since the City's informal wind design guidance criterion is 31 mph small changes in the natural wind field can result in exceedances of the criterion. Accordingly care must be taken in applying the informal wind design guidance, and in interpreting the significance of wind levels in Boston.

Extensive data describing mean wind speeds and effective gust velocities have been compiled and compared to the wind significance criteria introduced in Section 3. Existing wind velocities at six of the 47 PRE receptor locations exceed the informal wind design guidance level. The highest of these is 49 mph, which is well above the 31

mph city design guidance criterion. These areas of elevated pedestrian wind levels reflect Boston's high ambient wind levels and the effects of existing high-rise construction. These receptor locations include:

- #2 Franklin/Congress @ 36 mph
- #24 Harbor Towers Site @ 37 mph
- #25 Harbor Towers Site @ 36 mph
- #32 Atlantic Avenue @ 49 mph
- #33 Atlantic Avenue @ 33 mph
- #34 Expressway/Pedestrian Bridge @ 34 mph

The introduction of International Place affects local wind environment in a complex manner. There are increases and decreases in wind speed, and areas in which no change takes place. The presence of International Place Phase II completed, generally increases wind speeds immediately adjacent to the project site. However, in all but two cases the modeled wind speeds do not exceed the City's informal wind design guidance criterion. The exceptions are:

- #37 Oliver Street, where effective gust velocity is 34 mph, only 3 mph above the design guidance criterion and 4 mph above the ambient Boston wind levels.
- #38 Oliver Street, where effective gust velocity is 35 mph, 4 mph above the design guidance criterion and 5 mph above ambient.

The introduction of International Place decreases wind levels at eleven locations. Sites #33 and #34, Atlantic Avenue and the pedestrian bridge above the expressway,

were brought from PRE levels above the City design guidance criterion (33 mph and 36) to levels at or near the 31 mph criterion.

One wind hot spot stands out in the analysis. It is location #32, on Atlantic Avenue, east of the International Place site. Its PRE, PH1 and PH2 effective gust levels are 49 mph, 47 mph and 53 mph respectively. These troublesome levels exist with or without the project. The project has relatively little effect on the elevated winds here.

These comparisons demonstrate that the International Place site is fairly representative of the wind environment in Boston. Potential wind impacts that could affect the types of pedestrian activity possibly are limited to the area within a half block of the International Place site, with most significant changes in wind speeds taking place on the site itself, or on its periphery. No passive recreation areas on or near the site are affected, and the sidewalks in the project vicinity remain acceptable for accommodating pedestrian traffic.

The changes in wind speeds are consistent with the types and magnitude of changes one should expect with the introduction of a high rise development at a previously open site in a windy city. The basic design of International Place has no unique characteristics which exaggerate pedestrian level winds. On the contrary, the wind tunnel results indicate the smooth cylindrical shapes of the high rise elements help minimize potential for increases in pedestrian level winds.

Therefore, test results lead to a conclusion that predicted pedestrian winds resulting from International Place are not excessive for Boston, and should not create an unpleasant pedestrian environment.

7. MITIGATION TESTING

7.1 Introduction

After completing the qualitative and quantitative wind tunnel testing programs the authors concluded that the development of International Place will result in acceptable wind environments at and near the site. No hazardous winds were created by the building elements. Furthermore the authors advised the Fort Hill Square Associates that the building designs and arrangements were sound from a wind engineering standpoint. No further examination of design modifications was deemed necessary.

Upon reviewing the results of the wind studies BRA staff suggested that mitigation testing would be appropriate despite the perceived lack of wind problems. BRA suggested, and the Fort Hill Square Associates agreed, that mitigation testing could be used to study improvements to the wind environment at the site despite the lack of problem areas. Where possible the potential for reducing wind speeds or minimizing increases in wind speeds could be investigated at various locations with or without high wind speeds.

A first step in the mitigation studies was determining which test locations should be reviewed in the mitigation analysis. In selecting the mitigation test locations the authors examined both locations in which the BRA 31 mph comfort criterion were exceeded during the quantitative tests, and sites where on-site mitigation was likely to be effective regardless of wind speeds. Each of the locations in which wind speeds exceeded the BRA 31 mph criterion was examined. At location #2, the north corner of the First National Bank, was deemed to be too distant to benefit from any mitigating measures (besides which wind speeds were marginally reduced by the PH2

Configuration). Sites 24, 25, and 26 at Harbor Towers and along Atlantic Avenue were also deemed too distant to benefit from mitigating measures at International Place. It was also concluded that the increases in wind speeds at these locations over the PRE configuration were more directly a result of the closer Rows and Fosters development.* Site #34, an existing wind "hot spot" at Hook Lobster, is across the surface artery from International Place and, therefore, too far to benefit from mitigation. This site is also equidistant from International Place and Rows and Fosters Wharf. As a result the slightly increased winds with the PH2 configuration may reflect changes attributable to both developments.

Sites #37 and #38 are located on the International Place site adjacent to project structures. Wind speeds increase by 15 mph and 14 mph, respectively, at these sites to reach the effective gust velocities of 34 mph and 35 mph that exceed the BRA comfort criterion. The authors concluded that while these wind speeds are tolerable these locations are appropriate candidates for mitigation testing since they are both project related, and within an area that can be affected by on-site modifications.

* The PRE test assumed that neither International Place nor Rows and Fosters Wharf were in place. The PH1 and PH2 test assume that both are in place. As a result many of the increased wind speeds show the cumulative effects of both developments. Those areas closest to International Place are probably more directly affected by it; those closer to Rows and Foster's Wharf, such as Harbor Towers and Atlantic Avenue, are more likely affected by it. Some increases are likely affected by both developments. This conclusion is supported by the wind data in Figure IV-26 of the Rows Wharf Development Final Environmental Impact Report, July 1984.

Rather than test only at this pair of sites, however, an expanded set of mitigation test sites was selected. Sites #39-47 and #18 were added.* The 10 additional test locations were added since they surround the site, because they have wind speeds that increase with the introduction of the project, and because each is a possible candidate for benefitting from on-site mitigation measures. By picking the more comprehensive list of test sites the analysis can also determine the geographic effectiveness of mitigating measures and ensure that the mitigating measures do not remove some problem areas while creating others.

7.2 Mitigation Scenarios

Two mitigation scenarios were tested - M1 and M2. Each is a modification of the PH2 configuration in which trees and canopies were placed around the perimeter of the site to provide shielding from high wind speeds. These scenarios were selected by the authors based on their experience in designing mitigation measures for other similar projects. The placement of the shielding relative to the building elements and receptor locations is shown in Figures 7.1 and 7.2 for scenarios M1 and M2, respectively. The scale model was outfitted with modifications representative of the trees and canopies, and a new series of wind tunnel tests were run. In the new test the same meteorological assumptions, data and input used for the original hot wire tests were used to ensure consistency of results.

The results of the mitigation scenario tests are presented and compared to the previous parallel data sets

* Site 46 in the existing case, however, is now indoors with the full construction of the International Place courtyard.

Figure 7.1 Mitigation Scenario - M1

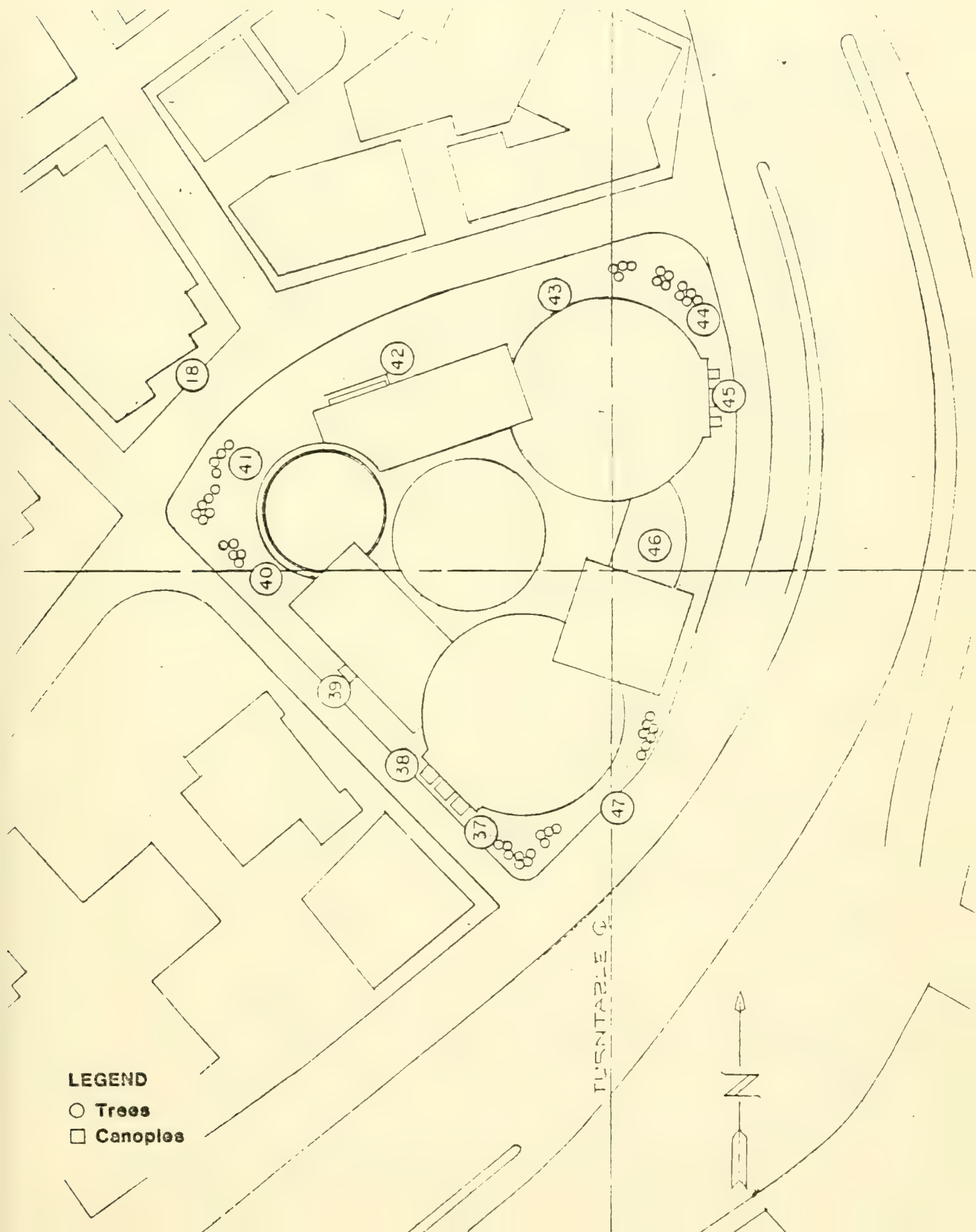
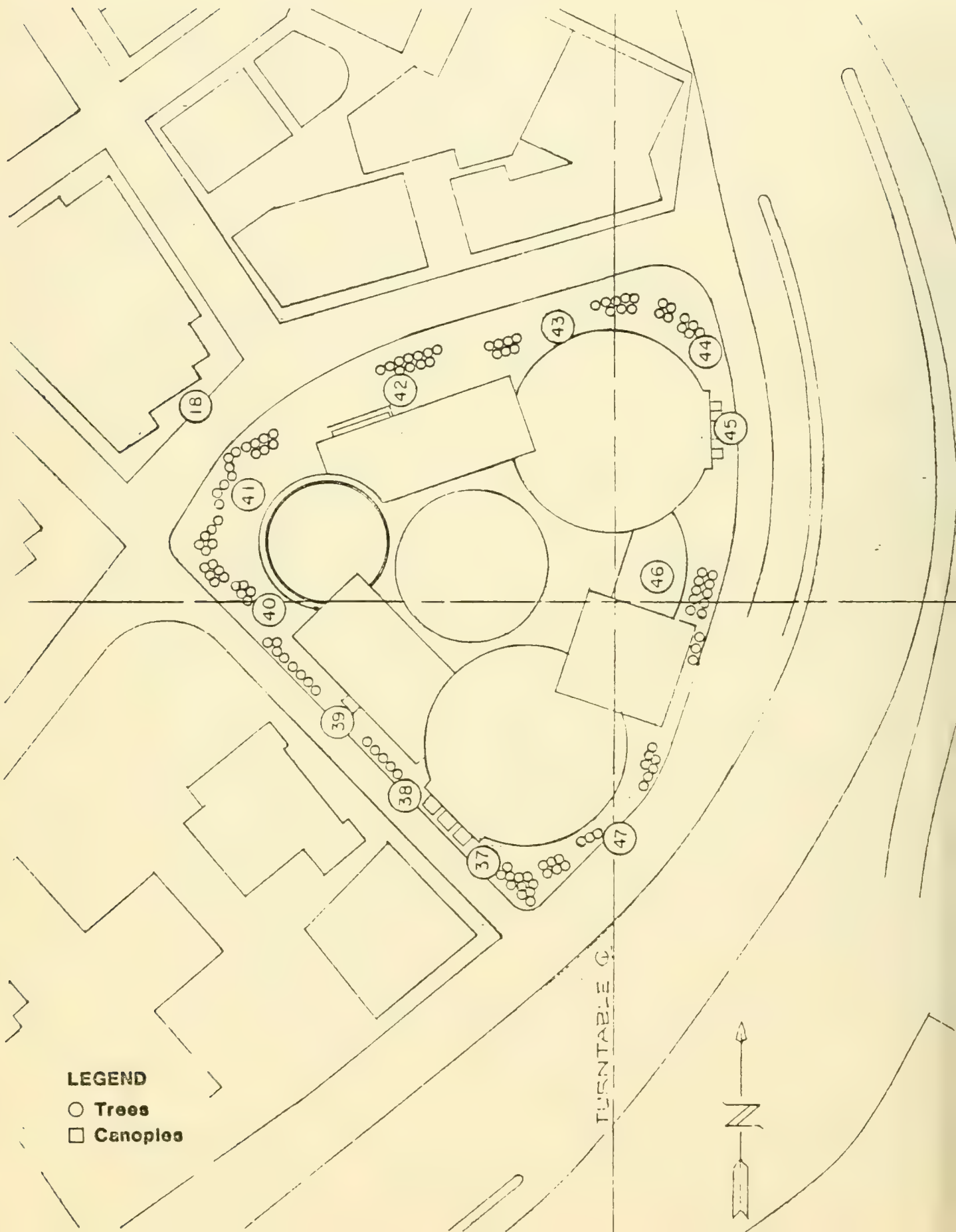


Figure 7.2 Mitigation Scenario - M2



in Table 7.1. The first column identifies the 12 test sites (#18 and #37-47). The following columns identify the effective gust velocities for PH2, M1 and M2 tests.

M1 Tests

The tests of the M1 mitigation scenario showed decreases in gust velocities at six sites, no change at another site, and increases at four of the eleven sites. Significant improvement (subjectively defined as reductions of 3 mph or more) in gust velocities occur at locations #42 and #44, along High Street, with the M1 mitigation scenario. At this pair of sites the gusts drop from 21 to 17 mph, and from 31 to 27 mph. These improvements, however, are more than offset by degradation at four other sites. Significant degradation (increases of 3 mph or more) occurs at sites #37 and #38 - the sites that already had the highest PH2 levels. Gust velocities increase from 34 and 35 mph, to 39 and 38 mph. Furthermore, at location #45 the relatively small increase in wind speeds pushes this site from 31 mph, a level just within the design criterion, to 32 mph. This leads to the conclusion that a partial implementation of M1 would likely be more effective than implementation of all the elements of the scenario. Retention of the plantings along High Street appears to be helpful; benefits of the other mitigating measures are not apparent. Neither the canopies nor the plantings on Oliver and Purchase Street appear to result in significant improvements in wind environment.

M2 Tests

Results of the M2 scenario showed greater potential for improvement in wind environment. Gust velocities

TABLE 7.1
EFFECTIVE GUST VELOCITIES (U+1.5 RMS)
EXCEEDED 1% OF THE TIME
MPH

<u>Location</u>	<u>PH2</u>	<u>M1</u>	<u>M2</u>
18	30	29(-1)	28(-2)
37	34	39(+5)	36(+2)**
38	35	38(+3)	40(+5)**
39	25	24(-1)	21(-4)
40	30	31(+1)	18(-12)
41	31	31 0	25(-6)
42	21	17(-4)	18(-3)
43	25	24(-1)	22(-3)
44	31	27(-4)	22(-9)
45	31	32(+1)	28(-3)
46*	30	N/A	N/A
47	30	29(-1)	27(-3)

* Site 46 in the existing case, however, is now indoors with the full construction of the International Place courtyard.

** Refer to page 8 for further wind reduction measures at these locations.

decreased at nine of the eleven locations, with increases at the remaining two. Very significant improvements (subjectively defined as reductions of 10 mph or more) were effected at locations #40 and #44. Significant improvements were observed at locations #39, #41-43, #45 and #47 as well. In total these improvements cover some 80% of the perimeter of the International Place site.

The increases in wind speeds occur only for the two locations #37 and #38 on Oliver Street. The increase at location #37 is small (2 mph); the increase at #38 is larger (5 mph) with a resultant gust velocity of 40 mph. These results lead to the conclusion that the M2 mitigation scenario is effective, except at the southwest edge of the site. At the entrance to the south tower and along Purchase Street the trees that have been added tend to channel winds rather than provide shielding. To provide shielding at this location it would be necessary to extend plantings across the full width of the sidewalk area to the south tower canopies. Such a dense planting plan could reduce wind speeds at these locations to the 20-25 mph range. In doing so, however, the dense plantings required could impinge upon pedestrian access and visual appeal of the entryways.

7.3 Conclusions

The International Place site is representative of the wind environment in Boston. The introduction of International Place will alter the effective gust velocities primarily on the streets and sidewalks immediately abutting the site. At these locations winds will be increased, but the expected increases result in acceptable conditions for pedestrian level activity. No passive recreation areas are affected and the streets remain suitable for pedestrian traffic.

The changes in wind speeds are consistent with the types and magnitude of changes one should expect at an exposed location in a windy city. The design has no unique characteristics which exaggerate pedestrian level winds. On the contrary, the wind tunnel results indicate the smooth cylindrical shapes of the high-rise elements help minimize potential for increases in pedestrian level winds.

Potential mitigating measures can be effective in reducing gust velocities at the International Place site. The M1 scenario demonstrates that a limited planting plan with canopies can provide some reductions in local winds along High Street. The M2 scenario demonstrates that an increased planting plan with canopies can provide more widespread reduction in wind levels. Reductions of wind speeds at about 80% of the site can be demonstrated. To accomplish these reductions the type of increased planting plan suggested by M2 is required. Within even more densely placed plantings wind reductions at virtually all locations on the site are possible. Such a plan suggests significant urban design penalties, however. These penalties include obstruction of pedestrian passage, particularly at the south corner of the site, and significant visual intrusion associated with over-planting. The visual intrusion would be greatest where plantings obscure the aesthetic integrity of entryways they attempt to shield from winds. It is evident to the authors that a hybrid of the two scenarios is a more appealing solution. The hybrid scenario can capture wind reductions associated with a modest, visually acceptable planting plan without overly disturbing the pedestrian environment.

In conclusion, the International Place development presents an acceptable wind environment with or without additional mitigating measures. The authors feel that the M1 and M2 mitigation tests have demonstrated that reductions in near site winds are possible, but question the need for implementing them. Should implementing measures be adopted the reductions in wind speed should be carefully considered in the context of overall urban design for the project. Reductions in already acceptable wind speeds should not be made at significant costs to pedestrian access and visual quality of major architectural elements.

APPENDIX A

QUANTITATIVE ANALYSIS STUDY APPROACH

Wind velocity measurements were performed in the environmental wind tunnel at Colorado State University (see Section 4.2). The same wind tunnel was used during the qualitative analysis (flow visualization study).

Vertical profiles of mean velocity and longitudinal turbulence intensity were measured upstream of the model to determine that an approach boundary layer flow appropriate to the site had been established. Approach profiles are specified in Section 4.3 of this study. Profiles were also obtained at the building site with the building removed to show the influences of surrounding buildings. In addition, mean velocity and turbulence intensity measurements were made 5 to 7 feet (full-scale) above the surface at each of the pedestrian locations for 16 wind directions.

The measurement locations are shown in Figure 6.1 of Section 6. The surface measurements indicate the wind environment to which a pedestrian at the measurement location would be subjected. The locations were chosen to determine the pedestrian environment on and near the project site prior to and after construction and at selected locations away from the project site.

Measurements were made with a single hot-film anemometer which was mounted with its axis vertical. The instrumentation used was a TSI, Inc. constant temperature anemometer (Model 1050) with a 0.002 inch diameter platinum film sensing element. Output was directed to the on-line data acquisition system for analysis.

Calibration of the hot-film anemometer was performed by comparing output with the reference Pitot-static probe in the wind tunnel. The calibration data were fit to a variable exponent King's law relationship of the form

$$E^2 = A + BV^C$$

where E is the hot-film output voltage, V the velocity and A, B and C are coefficients selected to fit the data. The above relationship was used to determine the mean velocity at measurement points using the measured mean voltage. The fluctuating velocity in the form V_{rms} (root-mean-square velocity) was obtained from:

$$V_{rms} = \frac{2 E E_{rms}}{B C V^{C-1}}$$

where E_{rms} is the root-mean-square (about the mean) voltage output from the anemometer. For interpretation, all turbulence measurements for pedestrian winds were divided by the mean velocity V_{inf} at 900 feet near the edge of the atmospheric boundary layer. Turbulence intensity in velocity profile measurements used the local mean velocity.

Mean velocity and turbulence intensity profiles for the boundary layer flow approaching the modeled area has the form

$$\frac{V}{V_{inf}} = \left[\frac{z}{z_{inf}} \right]^\alpha$$

in which V is the mean velocity at height z, V_{inf} is a reference wind speed at reference height z_{inf} at which the Pitot-static probe was mounted in the wind tunnel, and α is a constant which depends on the characteristics of the upstream roughness.

Three different approach profiles were to be used in the study. Those target profiles and the actual profiles obtained in the wind tunnel were:

Profile	Wind Directions	Power Law Exponent, α		Gradient
		Target	Wind Tunnel	Height
a)	25-125°	0.16	0.17	900
b)	125-215°	0.23	0.23	1200
c)	215-360°, 0-25°	0.30	0.29	1400

Measured profiles of longitudinal turbulence intensity in the flow approaching the modeled area and at the building site are shown in Figures B1 through B3. The turbulence intensities are appropriate for the approach mean velocity profiles selected. For the velocity profiles, turbulence intensity is defined as the root-mean-square about the mean of the longitudinal velocity fluctuations divided by the local mean velocity V as shown:

$$Tu = \frac{V_{rms}}{V}$$

Velocity data obtained at each of the pedestrian measurement locations shown in Figure 6.1 of Section 6 are listed in Table 2 of this Appendix as mean velocity V/V_{inf} , turbulence intensity V_{rms}/V_{inf} , and as the largest effective gust.

$$V_{pk} = \frac{V + 1.5V_{rms}}{V_{inf}}$$

The mean and peak velocities obtained 5 to 7 feet above ground level are plotted in polar form in Appendix C. The graphs show velocity magnitude and the approach wind direction for which that velocity was measured.

Mean velocity percentages above about 70 percent are quite high. High mean velocities for 3 to 5 or more approach wind azimuths for one location may indicate a highly windy environment. Values of V_{rms} are of concern

if they are above about 25 percent of V_{inf} --expecially if accompanied by a large mean velocity. Peak gusts, represented by $(V + 1.5 V_{rms})/V_{inf}$, in Table 2 of this Appendix can be considered as very large if above about 100 percent of V_R .

To enable a quantitative assessment of the wind environment, the wind-tunnel data were combined with wind frequency and direction information obtained at Logan International Airport as described in Section 4.4. These data, obtained at an elevation of 22 feet, were combined statistically with the wind-tunnel data of Table 2 (in this Appendix) to obtain cumulative probability distributions of wind speed for the full-scale site at each pedestrian measurement location. The distributions are plotted in Appendix D. These curves show, for each pedestrian location, the percent of time that a given mean velocity or effective peak velocity is exceeded at that location. Because pedestrians will tolerate higher wind speeds for a smaller period of time than for lower wind speeds, these curves provide a means of evaluating the overall acceptability of a pedestrian location.

TABLE 2--PEDESTRIAN WIND VELOCITIES AND TURBULENCE INTENSITIES
INTERNATIONAL PLACE PRE CONSTRUCTION SITE

LOCATION 13					LOCATION 14					LOCATION 15					LOCATION 16				
WIND AZIMUTH	U _{MEAN} /U _{INF} (PERCENT)	U _{RMS} /U _{INF} (PERCENT)	U _{MEAN} +1.5*U _{RMS} /U _{INF} (PERCENT)	WIND AZIMUTH	U _{MEAN} /U _{INF} (PERCENT)	U _{RMS} /U _{INF} (PERCENT)	U _{MEAN} +1.5*U _{RMS} /U _{INF} (PERCENT)	WIND AZIMUTH	U _{MEAN} /U _{INF} (PERCENT)	U _{RMS} /U _{INF} (PERCENT)	U _{MEAN} +1.5*U _{RMS} /U _{INF} (PERCENT)	WIND AZIMUTH	U _{MEAN} /U _{INF} (PERCENT)	U _{RMS} /U _{INF} (PERCENT)	U _{MEAN} +1.5*U _{RMS} /U _{INF} (PERCENT)	WIND AZIMUTH	U _{MEAN} /U _{INF} (PERCENT)	U _{RMS} /U _{INF} (PERCENT)	U _{MEAN} +1.5*U _{RMS} /U _{INF} (PERCENT)
00	1.5	1.1	3.2	00	2.8	2.0	6.7	00	2.3	1.9	6.2	00	2.3	1.9	6.2	00	2.3	1.9	6.2
45	1.5	1.2	3.4	45	2.9	2.1	6.8	45	2.4	2.0	6.4	45	2.4	2.0	6.4	45	2.4	2.0	6.4
90	1.5	1.1	3.3	90	2.8	2.0	6.7	90	2.3	1.9	6.2	90	2.3	1.9	6.2	90	2.3	1.9	6.2
135	1.5	1.0	3.2	135	2.7	1.9	6.6	135	2.2	1.8	6.1	135	2.2	1.8	6.1	135	2.2	1.8	6.1
180	1.5	1.0	3.2	180	2.7	1.9	6.6	180	2.2	1.8	6.1	180	2.2	1.8	6.1	180	2.2	1.8	6.1
225	1.5	1.0	3.2	225	2.7	1.9	6.6	225	2.2	1.8	6.1	225	2.2	1.8	6.1	225	2.2	1.8	6.1
270	1.5	1.0	3.2	270	2.7	1.9	6.6	270	2.2	1.8	6.1	270	2.2	1.8	6.1	270	2.2	1.8	6.1
315	1.5	1.0	3.2	315	2.7	1.9	6.6	315	2.2	1.8	6.1	315	2.2	1.8	6.1	315	2.2	1.8	6.1
360	1.5	1.0	3.2	360	2.7	1.9	6.6	360	2.2	1.8	6.1	360	2.2	1.8	6.1	360	2.2	1.8	6.1
00	1.5	1.1	3.2	00	2.8	2.0	6.7	00	2.3	1.9	6.2	00	2.3	1.9	6.2	00	2.3	1.9	6.2
45	1.5	1.2	3.4	45	2.9	2.1	6.8	45	2.4	2.0	6.4	45	2.4	2.0	6.4	45	2.4	2.0	6.4
90	1.5	1.1	3.3	90	2.8	2.0	6.7	90	2.3	1.9	6.2	90	2.3	1.9	6.2	90	2.3	1.9	6.2
135	1.5	1.0	3.2	135	2.7	1.9	6.6	135	2.2	1.8	6.1	135	2.2	1.8	6.1	135	2.2	1.8	6.1
180	1.5	1.0	3.2	180	2.7	1.9	6.6	180	2.2	1.8	6.1	180	2.2	1.8	6.1	180	2.2	1.8	6.1
225	1.5	1.0	3.2	225	2.7	1.9	6.6	225	2.2	1.8	6.1	225	2.2	1.8	6.1	225	2.2	1.8	6.1
270	1.5	1.0	3.2	270	2.7	1.9	6.6	270	2.2	1.8	6.1	270	2.2	1.8	6.1	270	2.2	1.8	6.1
315	1.5	1.0	3.2	315	2.7	1.9	6.6	315	2.2	1.8	6.1	315	2.2	1.8	6.1	315	2.2	1.8	6.1
360	1.5	1.0	3.2	360	2.7	1.9	6.6	360	2.2	1.8	6.1	360	2.2	1.8	6.1	360	2.2	1.8	6.1

TABLE 2--PEDESTRIAN WIND VELOCITIES AND TURBULENCE INTENSITIES
INTERNATIONAL PLACE FFE CONSTRUCTION SITE

LOCATION 17					LOCATION 19					LOCATION 20					
WIND AZIMUTH	U _{MEAN} /U _{INF} (PERCENT)	U _{PM} /U _{INF} (PERCENT)	U _{MEAN} +1.5 U _{PM} /U _{INF} (PERCENT)	WIND AZIMUTH	U _{MEAN} /U _{INF} (PERCENT)	U _{PM} /U _{INF} (PERCENT)	U _{MEAN} +1.5 U _{PM} /U _{INF} (PERCENT)	WIND AZIMUTH	U _{MEAN} /U _{INF} (PERCENT)	U _{PM} /U _{INF} (PERCENT)	U _{MEAN} +1.5 U _{PM} /U _{INF} (PERCENT)	WIND AZIMUTH	U _{MEAN} /U _{INF} (PERCENT)	U _{PM} /U _{INF} (PERCENT)	U _{MEAN} +1.5 U _{PM} /U _{INF} (PERCENT)
00	30	8	36	00	27	9	33	00	12	9	22	00	12	9	22
22	22	7	26	22	27	8	26	22	14	7	25	22	14	8	26
44	22	6	25	44	27	7	25	44	16	7	24	44	16	7	24
66	22	5	24	66	27	6	24	66	17	6	23	66	17	6	23
88	22	4	23	88	27	5	23	88	18	5	22	88	18	5	22
110	22	3	22	110	27	4	22	110	19	4	21	110	19	4	21
132	22	2	21	132	27	3	21	132	20	3	20	132	20	3	20
154	22	1	20	154	27	2	20	154	21	2	19	154	21	2	19
176	22	0	19	176	27	1	19	176	22	1	18	176	22	1	18
198	22	0	18	198	27	0	18	198	23	0	17	198	23	0	17
220	22	0	17	220	27	0	17	220	24	0	16	220	24	0	16
242	22	0	16	242	27	0	16	242	25	0	15	242	25	0	15
264	22	0	15	264	27	0	15	264	26	0	14	264	26	0	14
286	22	0	14	286	27	0	14	286	27	0	13	286	27	0	13
308	22	0	13	308	27	0	13	308	28	0	12	308	28	0	12
330	22	0	12	330	27	0	12	330	29	0	11	330	29	0	11
352	22	0	11	352	27	0	11	352	30	0	10	352	30	0	10
374	22	0	10	374	27	0	10	374	31	0	9	374	31	0	9
396	22	0	9	396	27	0	9	396	32	0	8	396	32	0	8
418	22	0	8	418	27	0	8	418	33	0	7	418	33	0	7
440	22	0	7	440	27	0	7	440	34	0	6	440	34	0	6
462	22	0	6	462	27	0	6	462	35	0	5	462	35	0	5
484	22	0	5	484	27	0	5	484	36	0	4	484	36	0	4
506	22	0	4	506	27	0	4	506	37	0	3	506	37	0	3
528	22	0	3	528	27	0	3	528	38	0	2	528	38	0	2
550	22	0	2	550	27	0	2	550	39	0	1	550	39	0	1
572	22	0	1	572	27	0	1	572	40	0	0	572	40	0	0
594	22	0	0	594	27	0	0	594	41	0	0	594	41	0	0
616	22	0	0	616	27	0	0	616	42	0	0	616	42	0	0
638	22	0	0	638	27	0	0	638	43	0	0	638	43	0	0
660	22	0	0	660	27	0	0	660	44	0	0	660	44	0	0
682	22	0	0	682	27	0	0	682	45	0	0	682	45	0	0
704	22	0	0	704	27	0	0	704	46	0	0	704	46	0	0
726	22	0	0	726	27	0	0	726	47	0	0	726	47	0	0
748	22	0	0	748	27	0	0	748	48	0	0	748	48	0	0
770	22	0	0	770	27	0	0	770	49	0	0	770	49	0	0
792	22	0	0	792	27	0	0	792	50	0	0	792	50	0	0
814	22	0	0	814	27	0	0	814	51	0	0	814	51	0	0
836	22	0	0	836	27	0	0	836	52	0	0	836	52	0	0
858	22	0	0	858	27	0	0	858	53	0	0	858	53	0	0
880	22	0	0	880	27	0	0	880	54	0	0	880	54	0	0
902	22	0	0	902	27	0	0	902	55	0	0	902	55	0	0
924	22	0	0	924	27	0	0	924	56	0	0	924	56	0	0
946	22	0	0	946	27	0	0	946	57	0	0	946	57	0	0
968	22	0	0	968	27	0	0	968	58	0	0	968	58	0	0
990	22	0	0	990	27	0	0	990	59	0	0	990	59	0	0
1012	22	0	0	1012	27	0	0	1012	60	0	0	1012	60	0	0
1034	22	0	0	1034	27	0	0	1034	61	0	0	1034	61	0	0
1056	22	0	0	1056	27	0	0	1056	62	0	0	1056	62	0	0
1078	22	0	0	1078	27	0	0	1078	63	0	0	1078	63	0	0
1100	22	0	0	1100	27	0	0	1100	64	0	0	1100	64	0	0
1122	22	0	0	1122	27	0	0	1122	65	0	0	1122	65	0	0
1144	22	0	0	1144	27	0	0	1144	66	0	0	1144	66	0	0
1166	22	0	0	1166	27	0	0	1166	67	0	0	1166	67	0	0
1188	22	0	0	1188	27	0	0	1188	68	0	0	1188	68	0	0
1210	22	0	0	1210	27	0	0	1210	69	0	0	1210	69	0	0
1232	22	0	0	1232	27	0	0	1232	70	0	0	1232	70	0	0
1254	22	0	0	1254	27	0	0	1254	71	0	0	1254	71	0	0
1276	22	0	0	1276	27	0	0	1276	72	0	0	1276	72	0	0
1298	22	0	0	1298	27	0	0	1298	73	0	0	1298	73	0	0
1320	22	0	0	1320	27	0	0	1320	74	0	0	1320	74	0	0
1342	22	0	0	1342	27	0	0	1342	75	0	0	1342	75	0	0
1364	22	0	0	1364	27	0	0	1364	76	0	0	1364	76	0	0
1386	22	0	0	1386	27	0	0	1386	77	0	0	1386	77	0	0
1408	22	0	0	1408	27	0	0	1408	78	0	0	1408	78	0	0
1430	22	0	0	1430	27	0	0	1430	79	0	0	1430	79	0	0
1452	22	0	0	1452	27	0	0	1452	80	0	0	1452	80	0	0
1474	22	0	0	1474	27	0	0	1474	81	0	0	1474	81	0	0
1496	22	0	0	1496	27	0	0	1496	82	0	0	1496	82	0	0
1518	22	0	0	1518	27	0	0	1518	83	0	0	1518	83	0	0
1540	22	0	0	1540	27	0	0	1540	84	0	0	1540	84	0	0
1562	22	0	0	1562	27	0	0	1562	85	0	0	1562	85	0	0
1584	22	0	0	1584	27	0	0	1584	86	0	0	1584	86	0	0
1606	22	0	0	1606	27	0	0	1606	87	0	0	1606	87	0	0
1628	22	0	0	1628	27	0	0	1628	88	0	0	1628	88	0	0
1650	22	0	0	1650	27	0	0	1650	89	0	0	1650	89	0	0
1672	22	0	0	1672	27	0	0	1672	90	0	0	1672	90	0	0
1694	22	0	0	1694	27	0	0	1694	91	0	0	1694	91	0	0
1716	22	0	0	1716	27	0	0	1716	92	0	0	1716	92	0	0
1738	22	0	0	1738	27	0	0	1738	93	0	0	1738	93	0	0
1760	22	0	0	1760	27	0	0	1760	94	0	0	1760	94	0	0
1782	22	0	0	1782	27	0	0	1782	95	0	0	1782	95	0	0
1804	22	0	0	1804	27	0	0	1804	96	0	0	1804	96	0	0
1826	22	0	0	1826	27	0	0	1826	97	0	0	1826	97	0	0
1848	22	0	0	1848	27	0	0	1848	98	0	0	1848	98	0	0
1870	22	0	0	1870	27	0	0	1870	99	0	0	1870	99	0	0
1892	22	0	0	1892	27	0	0	1892	100	0	0	1892	100	0	0

TABLE 2--PEDESTRIAN WIND VELOCITIES AND TURBULENCE INTENSITIES
INTERNATIONAL F-101 FPE CONSTRUCTION SITE

LOCATION 21					LOCATION 22				
WIND AZIMUTH	U/RMS/UINF (PERCENT)	U/RMS/UINF (PERCENT)	U/RMS/UINF (PERCENT)	U/RMS/UINF (PERCENT)	WIND AZIMUTH	U/RMS/UINF (PERCENT)	U/RMS/UINF (PERCENT)	U/RMS/UINF (PERCENT)	U/RMS/UINF (PERCENT)
00	10.2	10.2	10.2	10.2	00	12.2	12.2	12.2	12.2
22.5	10.2	10.2	10.2	10.2	22.5	12.2	12.2	12.2	12.2
45	10.2	10.2	10.2	10.2	45	12.2	12.2	12.2	12.2
67.5	10.2	10.2	10.2	10.2	67.5	12.2	12.2	12.2	12.2
90	10.2	10.2	10.2	10.2	90	12.2	12.2	12.2	12.2
112.5	10.2	10.2	10.2	10.2	112.5	12.2	12.2	12.2	12.2
135	10.2	10.2	10.2	10.2	135	12.2	12.2	12.2	12.2
157.5	10.2	10.2	10.2	10.2	157.5	12.2	12.2	12.2	12.2
180	10.2	10.2	10.2	10.2	180	12.2	12.2	12.2	12.2
202.5	10.2	10.2	10.2	10.2	202.5	12.2	12.2	12.2	12.2
225	10.2	10.2	10.2	10.2	225	12.2	12.2	12.2	12.2
247.5	10.2	10.2	10.2	10.2	247.5	12.2	12.2	12.2	12.2
270	10.2	10.2	10.2	10.2	270	12.2	12.2	12.2	12.2
292.5	10.2	10.2	10.2	10.2	292.5	12.2	12.2	12.2	12.2
315	10.2	10.2	10.2	10.2	315	12.2	12.2	12.2	12.2
337.5	10.2	10.2	10.2	10.2	337.5	12.2	12.2	12.2	12.2
360	10.2	10.2	10.2	10.2	360	12.2	12.2	12.2	12.2
382.5	10.2	10.2	10.2	10.2	382.5	12.2	12.2	12.2	12.2
405	10.2	10.2	10.2	10.2	405	12.2	12.2	12.2	12.2
427.5	10.2	10.2	10.2	10.2	427.5	12.2	12.2	12.2	12.2
450	10.2	10.2	10.2	10.2	450	12.2	12.2	12.2	12.2
472.5	10.2	10.2	10.2	10.2	472.5	12.2	12.2	12.2	12.2
495	10.2	10.2	10.2	10.2	495	12.2	12.2	12.2	12.2
517.5	10.2	10.2	10.2	10.2	517.5	12.2	12.2	12.2	12.2
540	10.2	10.2	10.2	10.2	540	12.2	12.2	12.2	12.2
562.5	10.2	10.2	10.2	10.2	562.5	12.2	12.2	12.2	12.2
585	10.2	10.2	10.2	10.2	585	12.2	12.2	12.2	12.2
607.5	10.2	10.2	10.2	10.2	607.5	12.2	12.2	12.2	12.2
630	10.2	10.2	10.2	10.2	630	12.2	12.2	12.2	12.2
652.5	10.2	10.2	10.2	10.2	652.5	12.2	12.2	12.2	12.2
675	10.2	10.2	10.2	10.2	675	12.2	12.2	12.2	12.2
697.5	10.2	10.2	10.2	10.2	697.5	12.2	12.2	12.2	12.2
720	10.2	10.2	10.2	10.2	720	12.2	12.2	12.2	12.2
742.5	10.2	10.2	10.2	10.2	742.5	12.2	12.2	12.2	12.2
765	10.2	10.2	10.2	10.2	765	12.2	12.2	12.2	12.2
787.5	10.2	10.2	10.2	10.2	787.5	12.2	12.2	12.2	12.2
810	10.2	10.2	10.2	10.2	810	12.2	12.2	12.2	12.2
832.5	10.2	10.2	10.2	10.2	832.5	12.2	12.2	12.2	12.2
855	10.2	10.2	10.2	10.2	855	12.2	12.2	12.2	12.2
877.5	10.2	10.2	10.2	10.2	877.5	12.2	12.2	12.2	12.2
900	10.2	10.2	10.2	10.2	900	12.2	12.2	12.2	12.2
922.5	10.2	10.2	10.2	10.2	922.5	12.2	12.2	12.2	12.2
945	10.2	10.2	10.2	10.2	945	12.2	12.2	12.2	12.2
967.5	10.2	10.2	10.2	10.2	967.5	12.2	12.2	12.2	12.2
990	10.2	10.2	10.2	10.2	990	12.2	12.2	12.2	12.2
1012.5	10.2	10.2	10.2	10.2	1012.5	12.2	12.2	12.2	12.2
1035	10.2	10.2	10.2	10.2	1035	12.2	12.2	12.2	12.2
1057.5	10.2	10.2	10.2	10.2	1057.5	12.2	12.2	12.2	12.2
1080	10.2	10.2	10.2	10.2	1080	12.2	12.2	12.2	12.2
1102.5	10.2	10.2	10.2	10.2	1102.5	12.2	12.2	12.2	12.2
1125	10.2	10.2	10.2	10.2	1125	12.2	12.2	12.2	12.2
1147.5	10.2	10.2	10.2	10.2	1147.5	12.2	12.2	12.2	12.2
1170	10.2	10.2	10.2	10.2	1170	12.2	12.2	12.2	12.2
1192.5	10.2	10.2	10.2	10.2	1192.5	12.2	12.2	12.2	12.2
1215	10.2	10.2	10.2	10.2	1215	12.2	12.2	12.2	12.2
1237.5	10.2	10.2	10.2	10.2	1237.5	12.2	12.2	12.2	12.2
1260	10.2	10.2	10.2	10.2	1260	12.2	12.2	12.2	12.2
1282.5	10.2	10.2	10.2	10.2	1282.5	12.2	12.2	12.2	12.2
1305	10.2	10.2	10.2	10.2	1305	12.2	12.2	12.2	12.2
1327.5	10.2	10.2	10.2	10.2	1327.5	12.2	12.2	12.2	12.2
1350	10.2	10.2	10.2	10.2	1350	12.2	12.2	12.2	12.2
1372.5	10.2	10.2	10.2	10.2	1372.5	12.2	12.2	12.2	12.2
1395	10.2	10.2	10.2	10.2	1395	12.2	12.2	12.2	12.2
1417.5	10.2	10.2	10.2	10.2	1417.5	12.2	12.2	12.2	12.2
1440	10.2	10.2	10.2	10.2	1440	12.2	12.2	12.2	12.2
1462.5	10.2	10.2	10.2	10.2	1462.5	12.2	12.2	12.2	12.2
1485	10.2	10.2	10.2	10.2	1485	12.2	12.2	12.2	12.2
1507.5	10.2	10.2	10.2	10.2	1507.5	12.2	12.2	12.2	12.2
1530	10.2	10.2	10.2	10.2	1530	12.2	12.2	12.2	12.2
1552.5	10.2	10.2	10.2	10.2	1552.5	12.2	12.2	12.2	12.2
1575	10.2	10.2	10.2	10.2	1575	12.2	12.2	12.2	12.2
1597.5	10.2	10.2	10.2	10.2	1597.5	12.2	12.2	12.2	12.2
1620	10.2	10.2	10.2	10.2	1620	12.2	12.2	12.2	12.2
1642.5	10.2	10.2	10.2	10.2	1642.5	12.2	12.2	12.2	12.2
1665	10.2	10.2	10.2	10.2	1665	12.2	12.2	12.2	12.2
1687.5	10.2	10.2	10.2	10.2	1687.5	12.2	12.2	12.2	12.2
1710	10.2	10.2	10.2	10.2	1710	12.2	12.2	12.2	12.2
1732.5	10.2	10.2	10.2	10.2	1732.5	12.2	12.2	12.2	12.2
1755	10.2	10.2	10.2	10.2	1755	12.2	12.2	12.2	12.2
1777.5	10.2	10.2	10.2	10.2	1777.5	12.2	12.2	12.2	12.2
1800	10.2	10.2	10.2	10.2	1800	12.2	12.2	12.2	12.2
1822.5	10.2	10.2	10.2	10.2	1822.5	12.2	12.2	12.2	12.2
1845	10.2	10.2	10.2	10.2	1845	12.2	12.2	12.2	12.2
1867.5	10.2	10.2	10.2	10.2	1867.5	12.2	12.2	12.2	12.2
1890	10.2	10.2	10.2	10.2	1890	12.2	12.2	12.2	12.2
1912.5	10.2	10.2	10.2	10.2	1912.5	12.2	12.2	12.2	12.2
1935	10.2	10.2	10.2	10.2	1935	12.2	12.2	12.2	12.2
1957.5	10.2	10.2	10.2	10.2	1957.5	12.2	12.2	12.2	12.2
1980	10.2	10.2	10.2	10.2	1980	12.2	12.2	12.2	12.2
2002.5	10.2	10.2	10.2	10.2	2002.5	12.2	12.2	12.2	12.2
2025	10.2	10.2	10.2	10.2	2025	12.2	12.2	12.2	12.2
2047.5	10.2	10.2	10.2	10.2	2047.5	12.2	12.2	12.2	12.2
2070	10.2	10.2	10.2	10.2	2070	12.2	12.2	12.2	12.2
2092.5	10.2	10.2	10.2	10.2	2092.5	12.2	12.2	12.2	12.2
2115	10.2	10.2	10.2	10.2	2115	12.2	12.2	12.2	12.2
2137.5	10.2	10.2	10.2	10.2	2137.5	12.2	12.2	12.2	12.2
2160	10.2	10.2	10.2	10.2	2160	12.2	12.2	12.2	12.2
2182.5	10.2	10.2	10.2	10.2	2182.5	12.2	12.2	12.2	12.2
2205	10.2	10.2	10.2	10.2	2205	12.2	12.2	12.2	12.2
2227.5	10.2	10.2	10.2	10.2	2227.5	12.2	12.2	12.2	12.2
2250	10.2	10.2	10.2	10.2	2250	12.2	12.2	12.2	12.2
2272.5	10.2	10.2	10.2	10.2	2272.5	12.2	12.2	12.2	12.2
2295	10.2	10.2	10.2	10.2	2295	12.2	12.2	12.2	12.2
2317.5	10.2	10.2	10.2	10.2	2317.5	12.2	12.2	12.2	12.2
2340	10.2	10.2	10.2	10.2	2340	12.2	12.2	12.2	12.2
2362.5	10.2	10.2	10.2	10.2	2362.5	12.2	12.2	12.2	12.2
2385	10.2	10.2	10.2	10.2	2385	12.2	12.2	12.2	12.2
2407.5	10.2	10.2	10.2	10.2	2407.5	12.2	12.2	12.2	12.2
2430	10.2	10.2	10.2	10.2	2430	12.2	12.2	12.2	12.2
2452.5	10.2	10.2	10.2	10.2	2452.5	12.2	12.2	12.2	12.2
2475	10.2	10.2	10.2	10.2	2475	12.2	12.2	12.2	12.2
2497.5	10.2	10.2	10.2	10.2	2497.5	12.2	12.2	12.2	12.2
2520	10.2	10.2	10.2	10.2	2520	12.2	12.2	12.2	12.2
2542.5	10.2	10.2	10.2	10.2	2542.5	12.2	12.2	12.2	12.2
2565	10.2	10.2	10.2	10.2	2565	12.2	12.2	12.2	12.2
2587.5	10.2	10.2	10.2	10.2	2587.5	12.2	12.2	12.2	12.2
2610	10.2	10.2	10.2	10.2	2610	12.2	12.2	12.2	12.2
2632.5	10.2	10.2	10.2	10.2	2632.5	12.2	12.2	12.2	12.2
2655	10.2	10.2	10.2	10.2	2655	12.2	12.2	12.2	12.2
2677.5	10.2	10.2	10.2	10.2	2677.5	12.2	12.2	12.2	12.2
2700	10.2	10.2	10.2	10.2	2700	12.2	12.2	12.2	12.2
2722.5	10.2	10.2	10.2	10.2	2722.5	12.2	12.2	12.2	12.2
2745	10.2	10.2	10.2	10.2	2745	12.2	12.2	12.2	12.2
2767.5	10.2	10.2	10.2	10.2	2767.5	12.2			

TABLE 2--PEDESTRIAN WIND VELOCITIES AND TURBULENCE INTENSITIES
INTERNATIONAL PLACE PPE CONSTRUCTION SITE

[illegible]

TABLE 2--PEDESTRIAN WIND VELOCITIES AND TURBULENCE INTENSITIES
INTERNATIONAL PLACE PRE CONSTRUCTION SITE

[illegible]

TABLE 2--PEDESTRIAN WIND VELOCITIES AND TURBULENCE INTENSITIES
INTERNATIONAL PLACE PPE CONSTRUCTION SITE

[illegible]

TABLE 2--PEDESTRIAN WIND VELOCITIES AND TURBULENCE INTENSITIES
INTERNATIONAL PLACE PRE CONSTRUCTION SITE

LOCATION 41					LOCATION 42					LOCATION 43					LOCATION 44				
WIND AZIMUTH	U _{MEAN} /U _{INF} (PERCENT)	U _{RMS} /U _{INF} (PERCENT)	U _{MEAN} +1.5*U _{RMS} /U _{INF} (PERCENT)	WIND AZIMUTH	WIND AZIMUTH	U _{MEAN} /U _{INF} (PERCENT)	U _{RMS} /U _{INF} (PERCENT)	U _{MEAN} +1.5*U _{RMS} /U _{INF} (PERCENT)	U _{RMS} /U _{INF} (PERCENT)	WIND AZIMUTH	U _{MEAN} /U _{INF} (PERCENT)	U _{RMS} /U _{INF} (PERCENT)	U _{MEAN} +1.5*U _{RMS} /U _{INF} (PERCENT)	U _{RMS} /U _{INF} (PERCENT)	WIND AZIMUTH	U _{MEAN} /U _{INF} (PERCENT)	U _{RMS} /U _{INF} (PERCENT)	U _{MEAN} +1.5*U _{RMS} /U _{INF} (PERCENT)	U _{RMS} /U _{INF} (PERCENT)
00	4	5	2	00	00	23	6	23	10	00	13	9	13	7	00	13	9	13	9
22	20	12	22	22	22	22	12	22	11	22	22	12	22	11	22	22	12	22	11
45	30	18	30	45	45	29	18	29	12	45	29	18	29	12	45	29	18	29	12
67	30	18	30	67	67	29	18	29	11	67	29	18	29	11	67	29	18	29	11
90	20	12	20	90	90	23	6	23	11	90	23	6	23	11	90	23	6	23	11
112	20	12	20	112	112	23	6	23	11	112	23	6	23	11	112	23	6	23	11
132	20	12	20	132	132	23	6	23	11	132	23	6	23	11	132	23	6	23	11
150	20	12	20	150	150	23	6	23	11	150	23	6	23	11	150	23	6	23	11
168	20	12	20	168	168	23	6	23	11	168	23	6	23	11	168	23	6	23	11
180	20	12	20	180	180	23	6	23	11	180	23	6	23	11	180	23	6	23	11
202	20	12	20	202	202	23	6	23	11	202	23	6	23	11	202	23	6	23	11
227	20	12	20	227	227	23	6	23	11	227	23	6	23	11	227	23	6	23	11
247	20	12	20	247	247	23	6	23	11	247	23	6	23	11	247	23	6	23	11
262	20	12	20	262	262	23	6	23	11	262	23	6	23	11	262	23	6	23	11
277	20	12	20	277	277	23	6	23	11	277	23	6	23	11	277	23	6	23	11
292	20	12	20	292	292	23	6	23	11	292	23	6	23	11	292	23	6	23	11
307	20	12	20	307	307	23	6	23	11	307	23	6	23	11	307	23	6	23	11
322	20	12	20	322	322	23	6	23	11	322	23	6	23	11	322	23	6	23	11
337	20	12	20	337	337	23	6	23	11	337	23	6	23	11	337	23	6	23	11
350	20	12	20	350	350	23	6	23	11	350	23	6	23	11	350	23	6	23	11
365	20	12	20	365	365	23	6	23	11	365	23	6	23	11	365	23	6	23	11
380	20	12	20	380	380	23	6	23	11	380	23	6	23	11	380	23	6	23	11
395	20	12	20	395	395	23	6	23	11	395	23	6	23	11	395	23	6	23	11
410	20	12	20	410	410	23	6	23	11	410	23	6	23	11	410	23	6	23	11
425	20	12	20	425	425	23	6	23	11	425	23	6	23	11	425	23	6	23	11
440	20	12	20	440	440	23	6	23	11	440	23	6	23	11	440	23	6	23	11
455	20	12	20	455	455	23	6	23	11	455	23	6	23	11	455	23	6	23	11
470	20	12	20	470	470	23	6	23	11	470	23	6	23	11	470	23	6	23	11
485	20	12	20	485	485	23	6	23	11	485	23	6	23	11	485	23	6	23	11
500	20	12	20	500	500	23	6	23	11	500	23	6	23	11	500	23	6	23	11
515	20	12	20	515	515	23	6	23	11	515	23	6	23	11	515	23	6	23	11
530	20	12	20	530	530	23	6	23	11	530	23	6	23	11	530	23	6	23	11
545	20	12	20	545	545	23	6	23	11	545	23	6	23	11	545	23	6	23	11
560	20	12	20	560	560	23	6	23	11	560	23	6	23	11	560	23	6	23	11
575	20	12	20	575	575	23	6	23	11	575	23	6	23	11	575	23	6	23	11
590	20	12	20	590	590	23	6	23	11	590	23	6	23	11	590	23	6	23	11
605	20	12	20	605	605	23	6	23	11	605	23	6	23	11	605	23	6	23	11
620	20	12	20	620	620	23	6	23	11	620	23	6	23	11	620	23	6	23	11
635	20	12	20	635	635	23	6	23	11	635	23	6	23	11	635	23	6	23	11
650	20	12	20	650	650	23	6	23	11	650	23	6	23	11	650	23	6	23	11
665	20	12	20	665	665	23	6	23	11	665	23	6	23	11	665	23	6	23	11
680	20	12	20	680	680	23	6	23	11	680	23	6	23	11	680	23	6	23	11
695	20	12	20	695	695	23	6	23	11	695	23	6	23	11	695	23	6	23	11
710	20	12	20	710	710	23	6	23	11	710	23	6	23	11	710	23	6	23	11
725	20	12	20	725	725	23	6	23	11	725	23	6	23	11	725	23	6	23	11
740	20	12	20	740	740	23	6	23	11	740	23	6	23	11	740	23	6	23	11
755	20	12	20	755	755	23	6	23	11	755	23	6	23	11	755	23	6	23	11
770	20	12	20	770	770	23	6	23	11	770	23	6	23	11	770	23	6	23	11
785	20	12	20	785	785	23	6	23	11	785	23	6	23	11	785	23	6	23	11
800	20	12	20	800	800	23	6	23	11	800	23	6	23	11	800	23	6	23	11
815	20	12	20	815	815	23	6	23	11	815	23	6	23	11	815	23	6	23	11
830	20	12	20	830	830	23	6	23	11	830	23	6	23	11	830	23	6	23	11
845	20	12	20	845	845	23	6	23	11	845	23	6	23	11	845	23	6	23	11
860	20	12	20	860	860	23	6	23	11	860	23	6	23	11	860	23	6	23	11
875	20	12	20	875	875	23	6	23	11	875	23	6	23	11	875	23	6	23	11
890	20	12	20	890	890	23	6	23	11	890	23	6	23	11	890	23	6	23	11
905	20	12	20	905	905	23	6	23	11	905	23	6	23	11	905	23	6	23	11
920	20	12	20	920	920	23	6	23	11	920	23	6	23	11	920	23	6	23	11
935	20	12	20	935	935	23	6	23	11	935	23	6	23	11	935	23	6	23	11
950	20	12	20	950	950	23	6	23	11	950	23	6	23	11	950	23	6	23	11
965	20	12	20	965	965	23	6	23	11	965	23	6	23	11	965	23	6	23	11
980	20	12	20	980	980	23	6	23	11	980	23	6	23	11	980	23	6	23	11
995	20	12	20	995	995	23	6	23	11	995	23	6	23	11	995	23	6	23	11

TABLE 2--PEDESTRIAN WIND VELOCITIES AND TURBULENCE INTENSITIES
INTERNATIONAL PLACE PPE CONSTRUCTION SITE

LOCATION 45					LOCATION 46					LOCATION 47					LOCATION 48						
WIND AZIMUTH	UMEAN/UINF (PERCENT)	UPRS/UINF (PERCENT)	UMEAN+1.5*UPRS/UINF (PERCENT)	WIND AZIMUTH	WIND AZIMUTH	UMEAN/UINF (PERCENT)	UPRS/UINF (PERCENT)	UMEAN+1.5*UPRS/UINF (PERCENT)	UPRS/UINF (PERCENT)	UMEAN/UINF (PERCENT)	UPRS/UINF (PERCENT)	UMEAN+1.5*UPRS/UINF (PERCENT)	UPRS/UINF (PERCENT)	UMEAN/UINF (PERCENT)	WIND AZIMUTH	WIND AZIMUTH	UMEAN/UINF (PERCENT)	UPRS/UINF (PERCENT)	UMEAN+1.5*UPRS/UINF (PERCENT)	UPRS/UINF (PERCENT)	UMEAN+1.5*UPRS/UINF (PERCENT)
0 00	2 0 1	10 2	4 1 0	0 00	0 00	1 0 2	4 1 0	4 1 0	6 4 7	4 3 0	1 0 0	4 3 0	1 0 0	6 1 5	0 00	0 00	4 3 0	1 0 0	6 1 5	1 0 0	6 1 5
2 30	3 0 1	12 9	4 9 1	2 30	2 30	12 9	4 9 1	4 9 1	10 0	4 3 0	2 30	4 3 0	1 0 0	6 1 5	2 30	2 30	4 3 0	1 0 0	6 1 5	1 0 0	6 1 5
4 30	3 0 1	12 9	4 9 1	4 30	4 30	12 9	4 9 1	4 9 1	10 0	4 3 0	4 30	4 3 0	1 0 0	6 1 5	4 30	4 30	4 3 0	1 0 0	6 1 5	1 0 0	6 1 5
6 30	3 0 1	12 9	4 9 1	6 30	6 30	12 9	4 9 1	4 9 1	10 0	4 3 0	6 30	4 3 0	1 0 0	6 1 5	6 30	6 30	4 3 0	1 0 0	6 1 5	1 0 0	6 1 5
8 30	3 0 1	12 9	4 9 1	8 30	8 30	12 9	4 9 1	4 9 1	10 0	4 3 0	8 30	4 3 0	1 0 0	6 1 5	8 30	8 30	4 3 0	1 0 0	6 1 5	1 0 0	6 1 5
10 30	3 0 1	12 9	4 9 1	10 30	10 30	12 9	4 9 1	4 9 1	10 0	4 3 0	10 30	4 3 0	1 0 0	6 1 5	10 30	10 30	4 3 0	1 0 0	6 1 5	1 0 0	6 1 5
12 30	3 0 1	12 9	4 9 1	12 30	12 30	12 9	4 9 1	4 9 1	10 0	4 3 0	12 30	4 3 0	1 0 0	6 1 5	12 30	12 30	4 3 0	1 0 0	6 1 5	1 0 0	6 1 5
14 30	3 0 1	12 9	4 9 1	14 30	14 30	12 9	4 9 1	4 9 1	10 0	4 3 0	14 30	4 3 0	1 0 0	6 1 5	14 30	14 30	4 3 0	1 0 0	6 1 5	1 0 0	6 1 5
16 30	3 0 1	12 9	4 9 1	16 30	16 30	12 9	4 9 1	4 9 1	10 0	4 3 0	16 30	4 3 0	1 0 0	6 1 5	16 30	16 30	4 3 0	1 0 0	6 1 5	1 0 0	6 1 5
18 30	3 0 1	12 9	4 9 1	18 30	18 30	12 9	4 9 1	4 9 1	10 0	4 3 0	18 30	4 3 0	1 0 0	6 1 5	18 30	18 30	4 3 0	1 0 0	6 1 5	1 0 0	6 1 5
20 30	3 0 1	12 9	4 9 1	20 30	20 30	12 9	4 9 1	4 9 1	10 0	4 3 0	20 30	4 3 0	1 0 0	6 1 5	20 30	20 30	4 3 0	1 0 0	6 1 5	1 0 0	6 1 5
22 30	3 0 1	12 9	4 9 1	22 30	22 30	12 9	4 9 1	4 9 1	10 0	4 3 0	22 30	4 3 0	1 0 0	6 1 5	22 30	22 30	4 3 0	1 0 0	6 1 5	1 0 0	6 1 5
24 30	3 0 1	12 9	4 9 1	24 30	24 30	12 9	4 9 1	4 9 1	10 0	4 3 0	24 30	4 3 0	1 0 0	6 1 5	24 30	24 30	4 3 0	1 0 0	6 1 5	1 0 0	6 1 5
26 30	3 0 1	12 9	4 9 1	26 30	26 30	12 9	4 9 1	4 9 1	10 0	4 3 0	26 30	4 3 0	1 0 0	6 1 5	26 30	26 30	4 3 0	1 0 0	6 1 5	1 0 0	6 1 5
28 30	3 0 1	12 9	4 9 1	28 30	28 30	12 9	4 9 1	4 9 1	10 0	4 3 0	28 30	4 3 0	1 0 0	6 1 5	28 30	28 30	4 3 0	1 0 0	6 1 5	1 0 0	6 1 5
30 30	3 0 1	12 9	4 9 1	30 30	30 30	12 9	4 9 1	4 9 1	10 0	4 3 0	30 30	4 3 0	1 0 0	6 1 5	30 30	30 30	4 3 0	1 0 0	6 1 5	1 0 0	6 1 5

TABLE 2--PEDESTRIAN WIND VELOCITIES AND TURBULENCE INTENSITIES
INTERMITTENT PLACE PHASE 1 WITH EVOLVING OFF-RAMP

LOCATION 1				LOCATION 2			
WIND AZIMUTH	UMEAN/UINF (PERCENT)	URMS/UINF (PERCENT)	UMEAN+1.5*URMS/UINF (PERCENT)	WIND AZIMUTH	UMEAN/UINF (PERCENT)	URMS/UINF (PERCENT)	UMEAN+1.5*URMS/UINF (PERCENT)
00	4.6	10.3	1.0	00	2.5	9.3	4.3
01	4.6	9.9	0.9	01	2.5	11.7	2.3
02	4.6	9.7	0.8	02	2.5	11.7	1.3
03	4.6	9.7	0.8	03	2.5	11.7	1.3
04	4.6	9.7	0.8	04	2.5	11.7	1.3
05	4.6	9.7	0.8	05	2.5	11.7	1.3
06	4.6	9.7	0.8	06	2.5	11.7	1.3
07	4.6	9.7	0.8	07	2.5	11.7	1.3
08	4.6	9.7	0.8	08	2.5	11.7	1.3
09	4.6	9.7	0.8	09	2.5	11.7	1.3
10	4.6	9.7	0.8	10	2.5	11.7	1.3
11	4.6	9.7	0.8	11	2.5	11.7	1.3
12	4.6	9.7	0.8	12	2.5	11.7	1.3
13	4.6	9.7	0.8	13	2.5	11.7	1.3
14	4.6	9.7	0.8	14	2.5	11.7	1.3
15	4.6	9.7	0.8	15	2.5	11.7	1.3
16	4.6	9.7	0.8	16	2.5	11.7	1.3
17	4.6	9.7	0.8	17	2.5	11.7	1.3
18	4.6	9.7	0.8	18	2.5	11.7	1.3
19	4.6	9.7	0.8	19	2.5	11.7	1.3
20	4.6	9.7	0.8	20	2.5	11.7	1.3
21	4.6	9.7	0.8	21	2.5	11.7	1.3
22	4.6	9.7	0.8	22	2.5	11.7	1.3
23	4.6	9.7	0.8	23	2.5	11.7	1.3
24	4.6	9.7	0.8	24	2.5	11.7	1.3
25	4.6	9.7	0.8	25	2.5	11.7	1.3
26	4.6	9.7	0.8	26	2.5	11.7	1.3
27	4.6	9.7	0.8	27	2.5	11.7	1.3
28	4.6	9.7	0.8	28	2.5	11.7	1.3
29	4.6	9.7	0.8	29	2.5	11.7	1.3
30	4.6	9.7	0.8	30	2.5	11.7	1.3
31	4.6	9.7	0.8	31	2.5	11.7	1.3
32	4.6	9.7	0.8	32	2.5	11.7	1.3
33	4.6	9.7	0.8	33	2.5	11.7	1.3
34	4.6	9.7	0.8	34	2.5	11.7	1.3
35	4.6	9.7	0.8	35	2.5	11.7	1.3
36	4.6	9.7	0.8	36	2.5	11.7	1.3
37	4.6	9.7	0.8	37	2.5	11.7	1.3
38	4.6	9.7	0.8	38	2.5	11.7	1.3
39	4.6	9.7	0.8	39	2.5	11.7	1.3
40	4.6	9.7	0.8	40	2.5	11.7	1.3
41	4.6	9.7	0.8	41	2.5	11.7	1.3
42	4.6	9.7	0.8	42	2.5	11.7	1.3
43	4.6	9.7	0.8	43	2.5	11.7	1.3
44	4.6	9.7	0.8	44	2.5	11.7	1.3
45	4.6	9.7	0.8	45	2.5	11.7	1.3
46	4.6	9.7	0.8	46	2.5	11.7	1.3
47	4.6	9.7	0.8	47	2.5	11.7	1.3
48	4.6	9.7	0.8	48	2.5	11.7	1.3
49	4.6	9.7	0.8	49	2.5	11.7	1.3
50	4.6	9.7	0.8	50	2.5	11.7	1.3
51	4.6	9.7	0.8	51	2.5	11.7	1.3
52	4.6	9.7	0.8	52	2.5	11.7	1.3
53	4.6	9.7	0.8	53	2.5	11.7	1.3
54	4.6	9.7	0.8	54	2.5	11.7	1.3
55	4.6	9.7	0.8	55	2.5	11.7	1.3
56	4.6	9.7	0.8	56	2.5	11.7	1.3
57	4.6	9.7	0.8	57	2.5	11.7	1.3
58	4.6	9.7	0.8	58	2.5	11.7	1.3
59	4.6	9.7	0.8	59	2.5	11.7	1.3
60	4.6	9.7	0.8	60	2.5	11.7	1.3
61	4.6	9.7	0.8	61	2.5	11.7	1.3
62	4.6	9.7	0.8	62	2.5	11.7	1.3
63	4.6	9.7	0.8	63	2.5	11.7	1.3
64	4.6	9.7	0.8	64	2.5	11.7	1.3
65	4.6	9.7	0.8	65	2.5	11.7	1.3
66	4.6	9.7	0.8	66	2.5	11.7	1.3
67	4.6	9.7	0.8	67	2.5	11.7	1.3
68	4.6	9.7	0.8	68	2.5	11.7	1.3
69	4.6	9.7	0.8	69	2.5	11.7	1.3
70	4.6	9.7	0.8	70	2.5	11.7	1.3
71	4.6	9.7	0.8	71	2.5	11.7	1.3
72	4.6	9.7	0.8	72	2.5	11.7	1.3
73	4.6	9.7	0.8	73	2.5	11.7	1.3
74	4.6	9.7	0.8	74	2.5	11.7	1.3
75	4.6	9.7	0.8	75	2.5	11.7	1.3
76	4.6	9.7	0.8	76	2.5	11.7	1.3
77	4.6	9.7	0.8	77	2.5	11.7	1.3
78	4.6	9.7	0.8	78	2.5	11.7	1.3
79	4.6	9.7	0.8	79	2.5	11.7	1.3
80	4.6	9.7	0.8	80	2.5	11.7	1.3
81	4.6	9.7	0.8	81	2.5	11.7	1.3
82	4.6	9.7	0.8	82	2.5	11.7	1.3
83	4.6	9.7	0.8	83	2.5	11.7	1.3
84	4.6	9.7	0.8	84	2.5	11.7	1.3
85	4.6	9.7	0.8	85	2.5	11.7	1.3
86	4.6	9.7	0.8	86	2.5	11.7	1.3
87	4.6	9.7	0.8	87	2.5	11.7	1.3
88	4.6	9.7	0.8	88	2.5	11.7	1.3
89	4.6	9.7	0.8	89	2.5	11.7	1.3
90	4.6	9.7	0.8	90	2.5	11.7	1.3
91	4.6	9.7	0.8	91	2.5	11.7	1.3
92	4.6	9.7	0.8	92	2.5	11.7	1.3
93	4.6	9.7	0.8	93	2.5	11.7	1.3
94	4.6	9.7	0.8	94	2.5	11.7	1.3
95	4.6	9.7	0.8	95	2.5	11.7	1.3
96	4.6	9.7	0.8	96	2.5	11.7	1.3
97	4.6	9.7	0.8	97	2.5	11.7	1.3
98	4.6	9.7	0.8	98	2.5	11.7	1.3
99	4.6	9.7	0.8	99	2.5	11.7	1.3
100	4.6	9.7	0.8	100	2.5	11.7	1.3

TABLE 2--PEDESTRIAN WIND VELOCITIES AND TURBULENCE INTENSITIES
INTERNATIONAL PLACE PHASE I WITH EXISTING OFF-RAMP

LOCATION 5					LOCATION 6					LOCATION 7					LOCATION 8				
WIND AZIMUTH	UMEAN/UIWF (PERCENT)	UPRS/UIWF (PERCENT)	UMEAN+1.5*UPRS/UIWF (PERCENT)	WIND AZIMUTH	WIND AZIMUTH	UMEAN/UIWF (PERCENT)	UPRS/UIWF (PERCENT)	UMEAN+1.5*UPRS/UIWF (PERCENT)	WIND AZIMUTH	WIND AZIMUTH	UMEAN/UIWF (PERCENT)	UPRS/UIWF (PERCENT)	UMEAN+1.5*UPRS/UIWF (PERCENT)	WIND AZIMUTH	WIND AZIMUTH	UMEAN/UIWF (PERCENT)	UPRS/UIWF (PERCENT)	UMEAN+1.5*UPRS/UIWF (PERCENT)	WIND AZIMUTH
00	17	3	26	00	00	30	9	43	00	00	27	6	37	00	00	27	6	47	00
06	14	3	24	06	22	40	2	40	06	22	39	1	40	06	22	39	1	40	06
12	14	3	24	12	28	40	2	40	12	28	40	2	40	12	28	40	2	40	12
18	14	3	24	18	34	40	2	40	18	34	40	2	40	18	34	40	2	40	18
24	14	3	24	24	40	40	2	40	24	40	40	2	40	24	40	40	2	40	24
30	14	3	24	30	46	40	2	40	30	46	40	2	40	30	46	40	2	40	30
36	14	3	24	36	52	40	2	40	36	52	40	2	40	36	52	40	2	40	36
42	14	3	24	42	58	40	2	40	42	58	40	2	40	42	58	40	2	40	42
48	14	3	24	48	64	40	2	40	48	64	40	2	40	48	64	40	2	40	48
54	14	3	24	54	70	40	2	40	54	70	40	2	40	54	70	40	2	40	54
60	14	3	24	60	76	40	2	40	60	76	40	2	40	60	76	40	2	40	60
66	14	3	24	66	82	40	2	40	66	82	40	2	40	66	82	40	2	40	66
72	14	3	24	72	88	40	2	40	72	88	40	2	40	72	88	40	2	40	72
78	14	3	24	78	94	40	2	40	78	94	40	2	40	78	94	40	2	40	78
84	14	3	24	84	00	40	2	40	84	00	40	2	40	84	00	40	2	40	84
90	14	3	24	90	06	40	2	40	90	06	40	2	40	90	06	40	2	40	90
96	14	3	24	96	12	40	2	40	96	12	40	2	40	96	12	40	2	40	96
102	14	3	24	102	18	40	2	40	102	18	40	2	40	102	18	40	2	40	102
108	14	3	24	108	24	40	2	40	108	24	40	2	40	108	24	40	2	40	108
114	14	3	24	114	30	40	2	40	114	30	40	2	40	114	30	40	2	40	114
120	14	3	24	120	36	40	2	40	120	36	40	2	40	120	36	40	2	40	120
126	14	3	24	126	42	40	2	40	126	42	40	2	40	126	42	40	2	40	126
132	14	3	24	132	48	40	2	40	132	48	40	2	40	132	48	40	2	40	132
138	14	3	24	138	54	40	2	40	138	54	40	2	40	138	54	40	2	40	138
144	14	3	24	144	60	40	2	40	144	60	40	2	40	144	60	40	2	40	144
150	14	3	24	150	66	40	2	40	150	66	40	2	40	150	66	40	2	40	150
156	14	3	24	156	72	40	2	40	156	72	40	2	40	156	72	40	2	40	156
162	14	3	24	162	78	40	2	40	162	78	40	2	40	162	78	40	2	40	162
168	14	3	24	168	84	40	2	40	168	84	40	2	40	168	84	40	2	40	168
174	14	3	24	174	90	40	2	40	174	90	40	2	40	174	90	40	2	40	174
180	14	3	24	180	96	40	2	40	180	96	40	2	40	180	96	40	2	40	180
186	14	3	24	186	02	40	2	40	186	02	40	2	40	186	02	40	2	40	186
192	14	3	24	192	08	40	2	40	192	08	40	2	40	192	08	40	2	40	192
198	14	3	24	198	14	40	2	40	198	14	40	2	40	198	14	40	2	40	198
204	14	3	24	204	20	40	2	40	204	20	40	2	40	204	20	40	2	40	204
210	14	3	24	210	26	40	2	40	210	26	40	2	40	210	26	40	2	40	210
216	14	3	24	216	32	40	2	40	216	32	40	2	40	216	32	40	2	40	216
222	14	3	24	222	38	40	2	40	222	38	40	2	40	222	38	40	2	40	222
228	14	3	24	228	44	40	2	40	228	44	40	2	40	228	44	40	2	40	228
234	14	3	24	234	50	40	2	40	234	50	40	2	40	234	50	40	2	40	234
240	14	3	24	240	56	40	2	40	240	56	40	2	40	240	56	40	2	40	240
246	14	3	24	246	62	40	2	40	246	62	40	2	40	246	62	40	2	40	246
252	14	3	24	252	68	40	2	40	252	68	40	2	40	252	68	40	2	40	252
258	14	3	24	258	74	40	2	40	258	74	40	2	40	258	74	40	2	40	258
264	14	3	24	264	80	40	2	40	264	80	40	2	40	264	80	40	2	40	264
270	14	3	24	270	86	40	2	40	270	86	40	2	40	270	86	40	2	40	270
276	14	3	24	276	92	40	2	40	276	92	40	2	40	276	92	40	2	40	276
282	14	3	24	282	98	40	2	40	282	98	40	2	40	282	98	40	2	40	282
288	14	3	24	288	04	40	2	40	288	04	40	2	40	288	04	40	2	40	288
294	14	3	24	294	10	40	2	40	294	10	40	2	40	294	10	40	2	40	294
300	14	3	24	300	16	40	2	40	300	16	40	2	40	300	16	40	2	40	300
306	14	3	24	306	22	40	2	40	306	22	40	2	40	306	22	40	2	40	306
312	14	3	24	312	28	40	2	40	312	28	40	2	40	312	28	40	2	40	312
318	14	3	24	318	34	40	2	40	318	34	40	2	40	318	34	40	2	40	318
324	14	3	24	324	40	40	2	40	324	40	40	2	40	324	40	40	2	40	324
330	14	3	24	330	46	40	2	40	330	46	40	2	40	330	46	40	2	40	330
336	14	3	24	336	52	40	2	40	336	52	40	2	40	336	52	40	2	40	336
342	14	3	24	342	58	40	2	40	342	58	40	2	40	342	58	40	2	40	342
348	14	3	24	348	64	40	2	40	348	64	40	2	40	348	64	40	2	40	348
354	14	3	24	354	70	40	2	40	354	70	40	2	40	354	70	40	2	40	354
360	14	3	24	360	76	40	2	40	360	76	40	2	40	360	76	40	2	40	360

TABLE 2--PEDESTRIAN WIND VELOCITIES AND TURBULENCE INTENSITIES
INTERNATIONAL PLACE PHASE I WITH EXISTING OFF-RAMP

LOCATION 9					LOCATION 10					LOCATION 11					LOCATION 12				
WIND AZIMUTH	UMEAN/UINF (PERCENT)	UMPS/UINF (PERCENT)	UMEAN+1.5UMPS/UINF (PERCENT)	WIND AZIMUTH	UMEAN/UINF (PERCENT)	UMPS/UINF (PERCENT)	UMEAN+1.5UMPS/UINF (PERCENT)	WIND AZIMUTH	UMEAN/UINF (PERCENT)	UMPS/UINF (PERCENT)	UMEAN+1.5UMPS/UINF (PERCENT)	WIND AZIMUTH	UMEAN/UINF (PERCENT)	UMPS/UINF (PERCENT)	UMEAN+1.5UMPS/UINF (PERCENT)	WIND AZIMUTH	UMEAN/UINF (PERCENT)	UMPS/UINF (PERCENT)	UMEAN+1.5UMPS/UINF (PERCENT)
00	28	10	40	00	13	20	40	00	20	40	40	00	20	40	40	00	20	40	40
30	28	10	40	30	13	12	30	30	20	30	30	30	20	30	30	30	20	30	30
45	28	10	40	45	13	11	30	45	20	30	30	45	20	30	30	45	20	30	30
60	28	10	40	60	13	11	30	60	20	30	30	60	20	30	30	60	20	30	30
75	28	10	40	75	13	11	30	75	20	30	30	75	20	30	30	75	20	30	30
90	28	10	40	90	13	11	30	90	20	30	30	90	20	30	30	90	20	30	30
105	28	10	40	105	13	11	30	105	20	30	30	105	20	30	30	105	20	30	30
120	28	10	40	120	13	11	30	120	20	30	30	120	20	30	30	120	20	30	30
135	28	10	40	135	13	11	30	135	20	30	30	135	20	30	30	135	20	30	30
150	28	10	40	150	13	11	30	150	20	30	30	150	20	30	30	150	20	30	30
165	28	10	40	165	13	11	30	165	20	30	30	165	20	30	30	165	20	30	30
180	28	10	40	180	13	11	30	180	20	30	30	180	20	30	30	180	20	30	30
195	28	10	40	195	13	11	30	195	20	30	30	195	20	30	30	195	20	30	30
210	28	10	40	210	13	11	30	210	20	30	30	210	20	30	30	210	20	30	30
225	28	10	40	225	13	11	30	225	20	30	30	225	20	30	30	225	20	30	30
240	28	10	40	240	13	11	30	240	20	30	30	240	20	30	30	240	20	30	30
255	28	10	40	255	13	11	30	255	20	30	30	255	20	30	30	255	20	30	30
270	28	10	40	270	13	11	30	270	20	30	30	270	20	30	30	270	20	30	30
285	28	10	40	285	13	11	30	285	20	30	30	285	20	30	30	285	20	30	30
300	28	10	40	300	13	11	30	300	20	30	30	300	20	30	30	300	20	30	30
315	28	10	40	315	13	11	30	315	20	30	30	315	20	30	30	315	20	30	30
330	28	10	40	330	13	11	30	330	20	30	30	330	20	30	30	330	20	30	30
345	28	10	40	345	13	11	30	345	20	30	30	345	20	30	30	345	20	30	30
360	28	10	40	360	13	11	30	360	20	30	30	360	20	30	30	360	20	30	30

TABLE 2--PEDESTRIAN WIND VELOCITIES AND TURBULENCE INTENSITIES
INTERNATIONAL PLACE PHASE I WITH EXISTING OFF-RAMP

[illegible][illegible]

TABLE 2--PEDESTRIAN WIND VELOCITIES AND TURBULENCE INTENSITIES
INTERNATIONAL PLACE PHASE I WITH EXISTING OFF-PUMP

[illegible][illegible]

TABLE 2--PEDESTRIAN WIND VELOCITIES AND TURBULENCE INTENSITIES
INTERNATIONAL PLACE PHASE I WITH EXISTING OFF-RAMP

LOCATION 21				LOCATION 22			
WIND AZIMUTH	U _{MEAN} /U _{INF} (PERCENT)	U _{RMS} /U _{INF} (PERCENT)	U _{MEAN} +1.5 U _{RMS} /U _{INF} (PERCENT)	WIND AZIMUTH	U _{MEAN} /U _{INF} (PERCENT)	U _{RMS} /U _{INF} (PERCENT)	U _{MEAN} +1.5 U _{RMS} /U _{INF} (PERCENT)
00	15	16	21	00	13	5	21
30	14	15	20	30	20	14	27
45	14	15	19	45	19	14	27
60	14	15	19	60	19	14	27
75	14	15	19	75	19	14	27
90	14	15	19	90	19	14	27
105	14	15	19	105	19	14	27
120	14	15	19	120	19	14	27
135	14	15	19	135	19	14	27
150	14	15	19	150	19	14	27
165	14	15	19	165	19	14	27
180	14	15	19	180	19	14	27
195	14	15	19	195	19	14	27
210	14	15	19	210	19	14	27
225	14	15	19	225	19	14	27
240	14	15	19	240	19	14	27
255	14	15	19	255	19	14	27
270	14	15	19	270	19	14	27
285	14	15	19	285	19	14	27
300	14	15	19	300	19	14	27
315	14	15	19	315	19	14	27
330	14	15	19	330	19	14	27
345	14	15	19	345	19	14	27
360	14	15	19	360	19	14	27
375	14	15	19	375	19	14	27
390	14	15	19	390	19	14	27
405	14	15	19	405	19	14	27
420	14	15	19	420	19	14	27
435	14	15	19	435	19	14	27
450	14	15	19	450	19	14	27
465	14	15	19	465	19	14	27
480	14	15	19	480	19	14	27
495	14	15	19	495	19	14	27
510	14	15	19	510	19	14	27
525	14	15	19	525	19	14	27
540	14	15	19	540	19	14	27
555	14	15	19	555	19	14	27
570	14	15	19	570	19	14	27
585	14	15	19	585	19	14	27
600	14	15	19	600	19	14	27
615	14	15	19	615	19	14	27
630	14	15	19	630	19	14	27
645	14	15	19	645	19	14	27
660	14	15	19	660	19	14	27
675	14	15	19	675	19	14	27
690	14	15	19	690	19	14	27
705	14	15	19	705	19	14	27
720	14	15	19	720	19	14	27
735	14	15	19	735	19	14	27
750	14	15	19	750	19	14	27
765	14	15	19	765	19	14	27
780	14	15	19	780	19	14	27
795	14	15	19	795	19	14	27
810	14	15	19	810	19	14	27
825	14	15	19	825	19	14	27
840	14	15	19	840	19	14	27
855	14	15	19	855	19	14	27
870	14	15	19	870	19	14	27
885	14	15	19	885	19	14	27
900	14	15	19	900	19	14	27
915	14	15	19	915	19	14	27
930	14	15	19	930	19	14	27
945	14	15	19	945	19	14	27
960	14	15	19	960	19	14	27
975	14	15	19	975	19	14	27
990	14	15	19	990	19	14	27
1005	14	15	19	1005	19	14	27
1020	14	15	19	1020	19	14	27
1035	14	15	19	1035	19	14	27
1050	14	15	19	1050	19	14	27
1065	14	15	19	1065	19	14	27
1080	14	15	19	1080	19	14	27
1095	14	15	19	1095	19	14	27
1110	14	15	19	1110	19	14	27
1125	14	15	19	1125	19	14	27
1140	14	15	19	1140	19	14	27
1155	14	15	19	1155	19	14	27
1170	14	15	19	1170	19	14	27
1185	14	15	19	1185	19	14	27
1200	14	15	19	1200	19	14	27
1215	14	15	19	1215	19	14	27
1230	14	15	19	1230	19	14	27
1245	14	15	19	1245	19	14	27
1260	14	15	19	1260	19	14	27
1275	14	15	19	1275	19	14	27
1290	14	15	19	1290	19	14	27
1305	14	15	19	1305	19	14	27
1320	14	15	19	1320	19	14	27
1335	14	15	19	1335	19	14	27
1350	14	15	19	1350	19	14	27
1365	14	15	19	1365	19	14	27
1380	14	15	19	1380	19	14	27
1395	14	15	19	1395	19	14	27
1410	14	15	19	1410	19	14	27
1425	14	15	19	1425	19	14	27
1440	14	15	19	1440	19	14	27
1455	14	15	19	1455	19	14	27
1470	14	15	19	1470	19	14	27
1485	14	15	19	1485	19	14	27
1500	14	15	19	1500	19	14	27
1515	14	15	19	1515	19	14	27
1530	14	15	19	1530	19	14	27
1545	14	15	19	1545	19	14	27
1560	14	15	19	1560	19	14	27
1575	14	15	19	1575	19	14	27
1590	14	15	19	1590	19	14	27
1605	14	15	19	1605	19	14	27
1620	14	15	19	1620	19	14	27
1635	14	15	19	1635	19	14	27
1650	14	15	19	1650	19	14	27
1665	14	15	19	1665	19	14	27
1680	14	15	19	1680	19	14	27
1695	14	15	19	1695	19	14	27
1710	14	15	19	1710	19	14	27
1725	14	15	19	1725	19	14	27
1740	14	15	19	1740	19	14	27
1755	14	15	19	1755	19	14	27
1770	14	15	19	1770	19	14	27
1785	14	15	19	1785	19	14	27
1800	14	15	19	1800	19	14	27
1815	14	15	19	1815	19	14	27
1830	14	15	19	1830	19	14	27
1845	14	15	19	1845	19	14	27
1860	14	15	19	1860	19	14	27
1875	14	15	19	1875	19	14	27
1890	14	15	19	1890	19	14	27
1905	14	15	19	1905	19	14	27
1920	14	15	19	1920	19	14	27
1935	14	15	19	1935	19	14	27
1950	14	15	19	1950	19	14	27
1965	14	15	19	1965	19	14	27
1980	14	15	19	1980	19	14	27
1995	14	15	19	1995	19	14	27
2010	14	15	19	2010	19	14	27
2025	14	15	19	2025	19	14	27
2040	14	15	19	2040	19	14	27
2055	14	15	19	2055	19	14	27
2070	14	15	19	2070	19	14	27
2085	14	15	19	2085	19	14	27
2100	14	15	19	2100	19	14	27
2115	14	15	19	2115	19	14	27
2130	14	15	19	2130	19	14	27
2145	14	15	19	2145	19	14	27
2160	14	15	19	2160	19	14	27
2175	14	15	19	2175	19	14	27
2190	14	15	19	2190	19	14	27
2205	14	15	19	2205	19	14	27
2220	14	15	19	2220	19	14	27
2235	14	15	19	2235	19	14	27
2250	14	15	19	2250	19	14	27
2265	14	15	19	2265	19	14	27
2280	14	15	19	2280	19	14	27
2295	14	15	19	2295	19	14	27
2310	14	15	19	2310	19	14	27
2325	14	15	19	2325	19	14	27
2340	14	15	19	2340	19	14	27
2355	14	15	19	2355	19	14	27
2370	14	15	19	2370	19	14	27
2385	14	15	19	2385	19	14	27
2400	14	15	19	2400	19	14	27
2415	14	15	19	2415	19	14	27
2430	14	15	19	2430	19	14	27
2445	14	15	19	2445	19	14	27
2460	14	15	19	2460	19	14	27
2475	14	15	19	2475	19	14	27
2490	14	15	19	2490	19	14	27
2505	14	15	19	2505	19	14	27
2520	14	15	19	2520	19	14	27
2535	14	15	19	2535	19	14	27
2550	14	15	19	2550	19	14	27
2565	14	15	19	2565	19	14	27
2580	14	15	19	2580	19	14	27
2595	14	15	19	2595	19	14	27
2610	14	15	19	2610	19	14	27
2625	14	15	19	2625	19	14	27
2640	14	15	19	2640	19	14	27
2655	14	15	19	2655	19	14	27
2670	14	15	19	2670	19	14	27
2685	14	15	19	2685	19	14	27
2700	14	15	19	2700	19	14	27
2715	14	15	19	2715	19	14	27
2730	14	15	19	2730	19	14	27
2745	14	15	19	2745	19	14	27
2760	14	15	19	2760	19	14	27
2775	14	15	19	2775	19	14	27
2790	14	15	19	2790	19	14	27
2805	14	15	19	2805	19	14	27
2820	14	15	19	2820	19	14	27
2835	14	15	19	2835	19	14	27
2850	14	15	19	2850	19	14	27
2865	14	15	19	2865	19	14	27
2880	14	15	19	2880	19	14	27

TABLE 2--PEDESTRIAN WIND VELOCITIES AND TURBULENCE INTENSITIES
INTERNATIONAL PLACE PHASE I WITH EXISTING OFF-PARK

LOCATION 23					
WIND AZIMUTH	UMEAN/UINF (PERCENT)	UPMS/UINF (PERCENT)	UMEAN+1.5*UPMS/UINF (PERCENT)	WIND AZIMUTH	UMEAN/UINF (PERCENT)
00	23	1	27	00	8
05	46	1	27	05	18
10	46	1	27	10	56
15	46	1	27	15	64
20	46	1	27	20	42
25	46	1	27	25	58
30	46	1	27	30	20
35	46	1	27	35	27
40	46	1	27	40	19
45	46	1	27	45	16
50	46	1	27	50	33
55	46	1	27	55	22
60	46	1	27	60	48
65	46	1	27	65	41
70	46	1	27	70	16
75	46	1	27	75	33
80	46	1	27	80	22
85	46	1	27	85	48
90	46	1	27	90	41
95	46	1	27	95	16
100	46	1	27	100	33
105	46	1	27	105	22
110	46	1	27	110	48
115	46	1	27	115	41
120	46	1	27	120	16
125	46	1	27	125	33
130	46	1	27	130	22
135	46	1	27	135	48
140	46	1	27	140	41
145	46	1	27	145	16
150	46	1	27	150	33
155	46	1	27	155	22
160	46	1	27	160	48
165	46	1	27	165	41
170	46	1	27	170	16
175	46	1	27	175	33
180	46	1	27	180	22
185	46	1	27	185	48
190	46	1	27	190	41
195	46	1	27	195	16
200	46	1	27	200	33
205	46	1	27	205	22
210	46	1	27	210	48
215	46	1	27	215	41
220	46	1	27	220	16
225	46	1	27	225	33
230	46	1	27	230	22
235	46	1	27	235	48
240	46	1	27	240	41
245	46	1	27	245	16
250	46	1	27	250	33
255	46	1	27	255	22
260	46	1	27	260	48
265	46	1	27	265	41
270	46	1	27	270	16
275	46	1	27	275	33
280	46	1	27	280	22
285	46	1	27	285	48
290	46	1	27	290	41
295	46	1	27	295	16
300	46	1	27	300	33
305	46	1	27	305	22
310	46	1	27	310	48
315	46	1	27	315	41
320	46	1	27	320	16
325	46	1	27	325	33
330	46	1	27	330	22
335	46	1	27	335	48
340	46	1	27	340	41
345	46	1	27	345	16
350	46	1	27	350	33
355	46	1	27	355	22
360	46	1	27	360	48
365	46	1	27	365	41
370	46	1	27	370	16
375	46	1	27	375	33
380	46	1	27	380	22
385	46	1	27	385	48
390	46	1	27	390	41
395	46	1	27	395	16
400	46	1	27	400	33
405	46	1	27	405	22
410	46	1	27	410	48
415	46	1	27	415	41
420	46	1	27	420	16
425	46	1	27	425	33
430	46	1	27	430	22
435	46	1	27	435	48
440	46	1	27	440	41
445	46	1	27	445	16
450	46	1	27	450	33
455	46	1	27	455	22
460	46	1	27	460	48
465	46	1	27	465	41
470	46	1	27	470	16
475	46	1	27	475	33
480	46	1	27	480	22
485	46	1	27	485	48
490	46	1	27	490	41
495	46	1	27	495	16
500	46	1	27	500	33
505	46	1	27	505	22
510	46	1	27	510	48
515	46	1	27	515	41
520	46	1	27	520	16
525	46	1	27	525	33
530	46	1	27	530	22
535	46	1	27	535	48
540	46	1	27	540	41
545	46	1	27	545	16
550	46	1	27	550	33
555	46	1	27	555	22
560	46	1	27	560	48
565	46	1	27	565	41
570	46	1	27	570	16
575	46	1	27	575	33
580	46	1	27	580	22
585	46	1	27	585	48
590	46	1	27	590	41
595	46	1	27	595	16
600	46	1	27	600	33
605	46	1	27	605	22
610	46	1	27	610	48
615	46	1	27	615	41
620	46	1	27	620	16
625	46	1	27	625	33
630	46	1	27	630	22
635	46	1	27	635	48
640	46	1	27	640	41
645	46	1	27	645	16
650	46	1	27	650	33
655	46	1	27	655	22
660	46	1	27	660	48
665	46	1	27	665	41
670	46	1	27	670	16
675	46	1	27	675	33
680	46	1	27	680	22
685	46	1	27	685	48
690	46	1	27	690	41
695	46	1	27	695	16
700	46	1	27	700	33
705	46	1	27	705	22
710	46	1	27	710	48
715	46	1	27	715	41
720	46	1	27	720	16
725	46	1	27	725	33
730	46	1	27	730	22
735	46	1	27	735	48
740	46	1	27	740	41
745	46	1	27	745	16
750	46	1	27	750	33
755	46	1	27	755	22
760	46	1	27	760	48
765	46	1	27	765	41
770	46	1	27	770	16
775	46	1	27	775	33
780	46	1	27	780	22
785	46	1	27	785	48
790	46	1	27	790	41
795	46	1	27	795	16
800	46	1	27	800	33
805	46	1	27	805	22
810	46	1	27	810	48
815	46	1	27	815	41
820	46	1	27	820	16
825	46	1	27	825	33
830	46	1	27	830	22
835	46	1	27	835	48
840	46	1	27	840	41
845	46	1	27	845	16
850	46	1	27	850	33
855	46	1	27	855	22
860	46	1	27	860	48
865	46	1	27	865	41
870	46	1	27	870	16
875	46	1	27	875	33
880	46	1	27	880	22
885	46	1	27	885	48
890	46	1	27	890	41
895	46	1	27	895	16
900	46	1	27	900	33
905	46	1	27	905	22
910	46	1	27	910	48
915	46	1	27	915	41
920	46	1	27	920	16
925	46	1	27	925	33
930	46	1	27	930	22
935	46	1	27	935	48
940	46	1	27	940	41
945	46	1	27	945	16
950	46	1	27	950	33
955	46	1	27	955	22
960	46	1	27	960	48
965	46	1	27	965	41
970	46	1	27	970	16
975	46	1	27	975	33
980	46	1	27	980	22
985	46	1	27	985	48
990	46	1	27	990	41
995	46	1	27	995	16
1000	46	1	27	1000	33

TABLE 2--PEDESTRIAN WIND VELOCITIES AND TURBULENCE INTENSITIES
INTERNATIONAL FLARE PHASE 1 WITH EXISTING OFF-RAMP

LOCATION 29					LOCATION 30					LOCATION 31					LOCATION 32				
WIND AZIMUTH	UWIND/UINF (PERCENT)	UWIND/UINF (PERCENT)	UWIND/UINF (PERCENT)	UWIND/UINF (PERCENT)	WIND AZIMUTH	UWIND/UINF (PERCENT)	UWIND/UINF (PERCENT)	UWIND/UINF (PERCENT)	UWIND/UINF (PERCENT)	WIND AZIMUTH	UWIND/UINF (PERCENT)	UWIND/UINF (PERCENT)	UWIND/UINF (PERCENT)	UWIND/UINF (PERCENT)	WIND AZIMUTH	UWIND/UINF (PERCENT)	UWIND/UINF (PERCENT)	UWIND/UINF (PERCENT)	UWIND/UINF (PERCENT)
00	15	11	10	10	00	15	11	10	10	00	15	11	10	10	00	15	11	10	10
25	10	10	10	10	25	10	10	10	10	25	10	10	10	10	25	10	10	10	10
50	10	10	10	10	50	10	10	10	10	50	10	10	10	10	50	10	10	10	10
75	10	10	10	10	75	10	10	10	10	75	10	10	10	10	75	10	10	10	10
100	10	10	10	10	100	10	10	10	10	100	10	10	10	10	100	10	10	10	10
125	10	10	10	10	125	10	10	10	10	125	10	10	10	10	125	10	10	10	10
150	10	10	10	10	150	10	10	10	10	150	10	10	10	10	150	10	10	10	10
175	10	10	10	10	175	10	10	10	10	175	10	10	10	10	175	10	10	10	10
200	10	10	10	10	200	10	10	10	10	200	10	10	10	10	200	10	10	10	10
225	10	10	10	10	225	10	10	10	10	225	10	10	10	10	225	10	10	10	10
250	10	10	10	10	250	10	10	10	10	250	10	10	10	10	250	10	10	10	10
275	10	10	10	10	275	10	10	10	10	275	10	10	10	10	275	10	10	10	10
300	10	10	10	10	300	10	10	10	10	300	10	10	10	10	300	10	10	10	10
325	10	10	10	10	325	10	10	10	10	325	10	10	10	10	325	10	10	10	10
350	10	10	10	10	350	10	10	10	10	350	10	10	10	10	350	10	10	10	10
375	10	10	10	10	375	10	10	10	10	375	10	10	10	10	375	10	10	10	10
400	10	10	10	10	400	10	10	10	10	400	10	10	10	10	400	10	10	10	10
425	10	10	10	10	425	10	10	10	10	425	10	10	10	10	425	10	10	10	10
450	10	10	10	10	450	10	10	10	10	450	10	10	10	10	450	10	10	10	10
475	10	10	10	10	475	10	10	10	10	475	10	10	10	10	475	10	10	10	10
500	10	10	10	10	500	10	10	10	10	500	10	10	10	10	500	10	10	10	10
525	10	10	10	10	525	10	10	10	10	525	10	10	10	10	525	10	10	10	10
550	10	10	10	10	550	10	10	10	10	550	10	10	10	10	550	10	10	10	10
575	10	10	10	10	575	10	10	10	10	575	10	10	10	10	575	10	10	10	10
600	10	10	10	10	600	10	10	10	10	600	10	10	10	10	600	10	10	10	10
625	10	10	10	10	625	10	10	10	10	625	10	10	10	10	625	10	10	10	10
650	10	10	10	10	650	10	10	10	10	650	10	10	10	10	650	10	10	10	10
675	10	10	10	10	675	10	10	10	10	675	10	10	10	10	675	10	10	10	10
700	10	10	10	10	700	10	10	10	10	700	10	10	10	10	700	10	10	10	10
725	10	10	10	10	725	10	10	10	10	725	10	10	10	10	725	10	10	10	10
750	10	10	10	10	750	10	10	10	10	750	10	10	10	10	750	10	10	10	10
775	10	10	10	10	775	10	10	10	10	775	10	10	10	10	775	10	10	10	10
800	10	10	10	10	800	10	10	10	10	800	10	10	10	10	800	10	10	10	10
825	10	10	10	10	825	10	10	10	10	825	10	10	10	10	825	10	10	10	10
850	10	10	10	10	850	10	10	10	10	850	10	10	10	10	850	10	10	10	10
875	10	10	10	10	875	10	10	10	10	875	10	10	10	10	875	10	10	10	10
900	10	10	10	10	900	10	10	10	10	900	10	10	10	10	900	10	10	10	10
925	10	10	10	10	925	10	10	10	10	925	10	10	10	10	925	10	10	10	10
950	10	10	10	10	950	10	10	10	10	950	10	10	10	10	950	10	10	10	10
975	10	10	10	10	975	10	10	10	10	975	10	10	10	10	975	10	10	10	10
1000	10	10	10	10	1000	10	10	10	10	1000	10	10	10	10	1000	10	10	10	10

TABLE 2--PEDESTRIAN WIND VELOCITIES AND TURBULENCE INTENSITIES
INTERNATIONAL PLACE PHASE I WITH EXISTING OFF-RAMP

[illegible]

TABLE 2--PEDESTRIAN WIND VELOCITIES AND TURBULENCE INTENSITIES
INTERNATIONAL PLACE PHASE 1 WITH EXISTING OFF-RAMP

LOCATION 37					LOCATION 38					LOCATION 39					LOCATION 40				
WIND AZIMUTH	U _{MEAN} /U _{INF} (PERCENT)	U _{RMS} /U _{INF} (PERCENT)	U _{MEAN} +1.5 U _{RMS} /U _{INF} (PERCENT)	U _{RMS} /U _{INF} (PERCENT)	WIND AZIMUTH	U _{MEAN} /U _{INF} (PERCENT)	U _{RMS} /U _{INF} (PERCENT)	U _{MEAN} +1.5 U _{RMS} /U _{INF} (PERCENT)	U _{RMS} /U _{INF} (PERCENT)	WIND AZIMUTH	U _{MEAN} /U _{INF} (PERCENT)	U _{RMS} /U _{INF} (PERCENT)	U _{MEAN} +1.5 U _{RMS} /U _{INF} (PERCENT)	U _{RMS} /U _{INF} (PERCENT)	WIND AZIMUTH	U _{MEAN} /U _{INF} (PERCENT)	U _{RMS} /U _{INF} (PERCENT)	U _{MEAN} +1.5 U _{RMS} /U _{INF} (PERCENT)	U _{RMS} /U _{INF} (PERCENT)
0 00	20 83	12 15	46 9	3 4	0 00	20 29	10 4	34 4	3 4	0 00	38 22	17 4	62 2	17 4	0 00	38 22	17 4	62 2	17 4
22 50	21 33	14 5	53 1	5 0	24 50	27 3	10 4	43 3	10 4	24 50	60 9	16 1	88 0	16 1	24 50	60 9	16 1	88 0	16 1
45 00	22 49	20 4	58 2	14 5	45 00	27 0	12 7	49 7	14 5	45 00	50 9	17 3	83 3	17 3	45 00	50 9	17 3	83 3	17 3
67 50	23 00	24 7	62 3	19 0	67 50	29 3	12 7	52 0	19 0	67 50	50 9	17 3	83 3	17 3	67 50	50 9	17 3	83 3	17 3
90 00	23 00	14 0	58 1	11 0	90 00	34 4	13 0	61 1	11 0	90 00	50 9	17 3	83 3	17 3	90 00	50 9	17 3	83 3	17 3
112 50	23 00	11 0	56 3	7 4	112 50	30 1	13 0	60 1	7 4	112 50	50 9	17 3	83 3	17 3	112 50	50 9	17 3	83 3	17 3
135 00	23 00	11 4	56 3	7 4	135 00	32 4	13 0	62 4	7 4	135 00	50 9	17 3	83 3	17 3	135 00	50 9	17 3	83 3	17 3
157 50	23 00	11 1	55 0	5 9	157 50	32 4	13 0	62 4	5 9	157 50	50 9	17 3	83 3	17 3	157 50	50 9	17 3	83 3	17 3
180 00	23 00	10 1	53 0	3 9	180 00	32 4	13 0	62 4	3 9	180 00	50 9	17 3	83 3	17 3	180 00	50 9	17 3	83 3	17 3
202 50	23 00	10 1	53 0	3 9	202 50	32 4	13 0	62 4	3 9	202 50	50 9	17 3	83 3	17 3	202 50	50 9	17 3	83 3	17 3
225 00	23 00	10 7	54 3	5 1	225 00	32 4	13 0	62 4	5 1	225 00	50 9	17 3	83 3	17 3	225 00	50 9	17 3	83 3	17 3
247 50	23 00	10 3	54 3	4 6	247 50	32 4	13 0	62 4	4 6	247 50	50 9	17 3	83 3	17 3	247 50	50 9	17 3	83 3	17 3
270 00	23 00	11 1	56 3	7 4	270 00	32 4	13 0	62 4	7 4	270 00	50 9	17 3	83 3	17 3	270 00	50 9	17 3	83 3	17 3
292 50	23 00	11 1	56 3	7 4	292 50	32 4	13 0	62 4	7 4	292 50	50 9	17 3	83 3	17 3	292 50	50 9	17 3	83 3	17 3
315 00	23 00	11 1	56 3	7 4	315 00	32 4	13 0	62 4	7 4	315 00	50 9	17 3	83 3	17 3	315 00	50 9	17 3	83 3	17 3
337 50	23 00	11 1	56 3	7 4	337 50	32 4	13 0	62 4	7 4	337 50	50 9	17 3	83 3	17 3	337 50	50 9	17 3	83 3	17 3
360 00	23 00	11 1	56 3	7 4	360 00	32 4	13 0	62 4	7 4	360 00	50 9	17 3	83 3	17 3	360 00	50 9	17 3	83 3	17 3
382 50	23 00	11 1	56 3	7 4	382 50	32 4	13 0	62 4	7 4	382 50	50 9	17 3	83 3	17 3	382 50	50 9	17 3	83 3	17 3
405 00	23 00	11 1	56 3	7 4	405 00	32 4	13 0	62 4	7 4	405 00	50 9	17 3	83 3	17 3	405 00	50 9	17 3	83 3	17 3
427 50	23 00	11 1	56 3	7 4	427 50	32 4	13 0	62 4	7 4	427 50	50 9	17 3	83 3	17 3	427 50	50 9	17 3	83 3	17 3
450 00	23 00	11 1	56 3	7 4	450 00	32 4	13 0	62 4	7 4	450 00	50 9	17 3	83 3	17 3	450 00	50 9	17 3	83 3	17 3
472 50	23 00	11 1	56 3	7 4	472 50	32 4	13 0	62 4	7 4	472 50	50 9	17 3	83 3	17 3	472 50	50 9	17 3	83 3	17 3
495 00	23 00	11 1	56 3	7 4	495 00	32 4	13 0	62 4	7 4	495 00	50 9	17 3	83 3	17 3	495 00	50 9	17 3	83 3	17 3
517 50	23 00	11 1	56 3	7 4	517 50	32 4	13 0	62 4	7 4	517 50	50 9	17 3	83 3	17 3	517 50	50 9	17 3	83 3	17 3
540 00	23 00	11 1	56 3	7 4	540 00	32 4	13 0	62 4	7 4	540 00	50 9	17 3	83 3	17 3	540 00	50 9	17 3	83 3	17 3
562 50	23 00	11 1	56 3	7 4	562 50	32 4	13 0	62 4	7 4	562 50	50 9	17 3	83 3	17 3	562 50	50 9	17 3	83 3	17 3
585 00	23 00	11 1	56 3	7 4	585 00	32 4	13 0	62 4	7 4	585 00	50 9	17 3	83 3	17 3	585 00	50 9	17 3	83 3	17 3
607 50	23 00	11 1	56 3	7 4	607 50	32 4	13 0	62 4	7 4	607 50	50 9	17 3	83 3	17 3	607 50	50 9	17 3	83 3	17 3
630 00	23 00	11 1	56 3	7 4	630 00	32 4	13 0	62 4	7 4	630 00	50 9	17 3	83 3	17 3	630 00	50 9	17 3	83 3	17 3
652 50	23 00	11 1	56 3	7 4	652 50	32 4	13 0	62 4	7 4	652 50	50 9	17 3	83 3	17 3	652 50	50 9	17 3	83 3	17 3
675 00	23 00	11 1	56 3	7 4	675 00	32 4	13 0	62 4	7 4	675 00	50 9	17 3	83 3	17 3	675 00	50 9	17 3	83 3	17 3
697 50	23 00	11 1	56 3	7 4	697 50	32 4	13 0	62 4	7 4	697 50	50 9	17 3	83 3	17 3	697 50	50 9	17 3	83 3	17 3
720 00	23 00	11 1	56 3	7 4	720 00	32 4	13 0	62 4	7 4	720 00	50 9	17 3	83 3	17 3	720 00	50 9	17 3	83 3	17 3
742 50	23 00	11 1	56 3	7 4	742 50	32 4	13 0	62 4	7 4	742 50	50 9	17 3	83 3	17 3	742 50	50 9	17 3	83 3	17 3
765 00	23 00	11 1	56 3	7 4	765 00	32 4	13 0	62 4	7 4	765 00	50 9	17 3	83 3	17 3	765 00	50 9	17 3	83 3	17 3
787 50	23 00	11 1	56 3	7 4	787 50	32 4	13 0	62 4	7 4	787 50	50 9	17 3	83 3	17 3	787 50	50 9	17 3	83 3	17 3
810 00	23 00	11 1	56 3	7 4	810 00	32 4	13 0	62 4	7 4	810 00	50 9	17 3	83 3	17 3	810 00	50 9	17 3	83 3	17 3
832 50	23 00	11 1	56 3	7 4	832 50	32 4	13 0	62 4	7 4	832 50	50 9	17 3	83 3	17 3	832 50	50 9	17 3	83 3	17 3
855 00	23 00	11 1	56 3	7 4	855 00	32 4	13 0	62 4	7 4	855 00	50 9	17 3	83 3	17 3	855 00	50 9	17 3	83 3	17 3
877 50	23 00	11 1	56 3	7 4	877 50	32 4	13 0	62 4	7 4	877 50	50 9	17 3	83 3	17 3	877 50	50 9	17 3	83 3	17 3
900 00	23 00	11 1	56 3	7 4	900 00	32 4	13 0	62 4	7 4	900 00	50 9	17 3	83 3	17 3	900 00	50 9	17 3	83 3	17 3
922 50	23 00	11 1	56 3	7 4	922 50	32 4	13 0	62 4	7 4	922 50	50 9	17 3	83 3	17 3	922 50	50 9	17 3	83 3	17 3
945 00	23 00	11 1	56 3	7 4	945 00	32 4	13 0	62 4	7 4	945 00	50 9	17 3	83 3	17 3	945 00	50 9	17 3	83 3	17 3
967 50	23 00	11 1	56 3	7 4	967 50	32 4	13 0	62 4	7 4	967 50	50 9	17 3	83 3	17 3	967 50	50 9	17 3	83 3	17 3
990 00	23 00	11 1	56 3	7 4	990 00	32 4	13 0	62 4	7 4	990 00	50 9	17 3	83 3	17 3	990 00	50 9	17 3	83 3	17 3
1012 50	23 00	11 1	56 3	7 4	1012 50	32 4	13 0	62 4	7 4	1012 50	50 9	17 3	83 3	17 3	1012 50	50 9	17 3	83 3	17 3
1035 00	23 00	11 1	56 3	7 4	1035 00	32 4	13 0	62 4	7 4	1035 00	50 9	17 3	83 3	17 3	1035 00	50 9	17 3	83 3	17 3
1057 50	23 00	11 1	56 3	7 4	1057 50	32 4	13 0	62 4	7 4	1057 50	50 9	17 3	83 3	17 3	1057 50	50 9	17 3	83 3	17 3
1080 00	23 00	11 1	56 3	7 4	1080 00	32 4	13 0	62 4	7 4	1080 00	50 9	17 3	83 3	17 3	1080 00	50 9	17 3	83 3	17 3
1102 50	23 00	11 1	56 3	7 4	1102 50	32 4	13 0	62 4	7 4	1102 50	50 9	17 3	83 3	17 3	1102 50	50 9	17 3	83 3	17 3
1125 00	23 00	11 1	56 3	7 4	1125 00	32 4	13 0	62 4	7 4	1125 00	50 9	17 3	83 3	17 3	1125 00	50 9	17 3	83 3	17 3
1147 50	23 00	11 1	56 3	7 4	1147 50	32 4	13 0	62 4	7 4	1147 50	50 9	17 3	83 3	17 3	1147 50	50 9	17 3	83 3	17 3
1170 00	23 00	11 1	56 3	7 4	1170 00	32 4	13 0	62 4	7 4	1170 00	50 9	17 3	83 3	17 3	1170 00	50 9	17 3	83 3	17 3
1192 50	23 00	11 1	56 3	7 4	1192 50	32 4	13 0	62 4	7 4	1192 50	50 9	17 3	83 3	17 3	1192 50	50 9	17 3	83 3	17 3
1215 00	23 00	11 1	56 3	7 4	1215 00	32 4	13 0	62 4	7 4	1215 00	50 9	17 3	83 3	17 3	1215 00	50 9	17 3	83 3	17 3
1237 50	23 00	11 1	56 3	7 4	1237 50	32 4	13 0	62 4	7 4	1237 50	50 9	17 3	83 3	17 3	1237 50	50 9	17 3	83 3	17 3
1260 00	23 00	11 1	56 3	7 4	1260 00	32 4	13 0	62 4	7 4	1260 00	50 9	17 3	83 3	17 3	1260 00	50 9	17 3	83 3	17 3
1282 50	23 00	11 1	56 3	7 4	1282 50	32 4	13 0	62 4	7 4	1282 50	50 9	17 3	83 3	17 3	1282 50	50 9	17 3	83 3	17 3
1305 00	23 00	11 1	56 3	7 4	1305 00	32 4	13 0	62 4	7 4	1305 00	50 9	17 3	83 3	17 3	1305 00	50 9	17 3	83 3	17 3
1327 50	23 00	11 1	56 3	7 4	1327 50	32 4	13 0	62 4	7 4	1327 50	50 9</								

TABLE 2--PEDESTRIAN WIND VELOCITIES AND TURBULENCE INTENSITIES
INTERNATIONAL PLACE PHASE I WITH EXISTING OFF-RAMP

LOCATION 41						LOCATION 42						LOCATION 43						LOCATION 44																	
WIND			URMS/UINF			UMEAN/UINF			UMEAN+1.5*URMS/UINF			WIND			URMS/UINF			UMEAN/UINF			UMEAN+1.5*URMS/UINF			WIND			URMS/UINF			UMEAN/UINF			UMEAN+1.5*URMS/UINF		
AZIMUTH			(PERCENT)			(PERCENT)			(PERCENT)			AZIMUTH			(PERCENT)			(PERCENT)			(PERCENT)			AZIMUTH			(PERCENT)			(PERCENT)			(PERCENT)		
00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00					
05	05	05	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00					
10	10	10	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00					
15	15	15	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00					
20	20	20	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00					
25	25	25	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00					
30	30	30	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00					
35	35	35	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00					
40	40	40	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00					
45	45	45	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00					
50	50	50	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00					
55	55	55	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00					
60	60	60	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00					
65	65	65	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00					
70	70	70	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00					
75	75	75	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00					
80	80	80	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00					
85	85	85	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00					
90	90	90	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00					
95	95	95	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00					
100	100	100	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00					
105	105	105	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00					
110	110	110	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00					
115	115	115	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00					
120	120	120	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00					
125	125	125	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00					
130	130	130	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00					
135	135	135	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00					
140	140	140	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00					
145	145	145	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00					
150	150	150	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00					
155	155	155	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00	00					
160	160	160	00	00	00	00	00	00	00	00	00	00	00	00																					

TABLE 2--PEDESTRIAN WIND VELOCITIES AND TURBULENCE INTENSITIES
INTERNATIONAL PLACE PHASE I WITH EXISTING OFF-RAMP

LOCATION 45					LOCATION 46						
WIND AZIMUTH	UMEAN/UINF (PERCENT)	URMS/UINF (PERCENT)	UMEAN+1.5*URMS/UINF (PERCENT)	WIND AZIMUTH	UMEAN/UINF (PERCENT)	URMS/UINF (PERCENT)	UMEAN+1.5*URMS/UINF (PERCENT)	WIND AZIMUTH	UMEAN/UINF (PERCENT)	URMS/UINF (PERCENT)	UMEAN+1.5*URMS/UINF (PERCENT)
00	42.2	14.1	48.1	00	34.3	19.8	49.8	00	34.3	19.8	49.8
24	22.2	12.6	46.2	22	42.2	13.6	76.6	24	42.2	13.6	76.6
48	22.4	10.8	40.2	42	46.0	13.9	62.6	48	46.0	13.9	62.6
72	22.4	10.6	40.2	60	33.3	13.6	69.3	72	33.3	13.6	69.3
96	22.1	13.6	47.2	78	68.4	22.8	107.1	96	68.4	22.8	107.1
120	62.1	14.7	49.1	96	66.9	19.4	107.1	120	66.9	19.4	107.1
144	22.3	14.0	48.1	114	39.3	14.1	68.0	144	39.3	14.1	68.0
168	22.8	14.2	48.1	132	31.8	17.7	73.0	168	31.8	17.7	73.0
192	18.7	16.3	43.0	150	20.4	17.7	72.2	192	18.7	16.3	43.0
216	18.3	16.3	43.0	168	11.2	15.9	72.9	216	18.3	16.3	43.0
240	17.4	16.3	43.0	186	11.3	13.7	71.0	240	17.4	16.3	43.0
264	17.2	16.3	43.0	204	23.8	13.7	71.0	264	17.2	16.3	43.0
288	17.2	16.3	43.0	222	11.2	13.7	71.0	288	17.2	16.3	43.0
312	17.2	16.3	43.0	240	11.2	13.7	71.0	312	17.2	16.3	43.0
336	17.2	16.3	43.0	258	11.2	13.7	71.0	336	17.2	16.3	43.0
360	17.2	16.3	43.0	276	11.2	13.7	71.0	360	17.2	16.3	43.0
384	17.2	16.3	43.0	294	11.2	13.7	71.0	384	17.2	16.3	43.0
408	17.2	16.3	43.0	312	11.2	13.7	71.0	408	17.2	16.3	43.0
432	17.2	16.3	43.0	330	11.2	13.7	71.0	432	17.2	16.3	43.0
456	17.2	16.3	43.0	348	11.2	13.7	71.0	456	17.2	16.3	43.0
480	17.2	16.3	43.0	366	11.2	13.7	71.0	480	17.2	16.3	43.0
504	17.2	16.3	43.0	384	11.2	13.7	71.0	504	17.2	16.3	43.0
528	17.2	16.3	43.0	402	11.2	13.7	71.0	528	17.2	16.3	43.0
552	17.2	16.3	43.0	420	11.2	13.7	71.0	552	17.2	16.3	43.0
576	17.2	16.3	43.0	438	11.2	13.7	71.0	576	17.2	16.3	43.0
600	17.2	16.3	43.0	456	11.2	13.7	71.0	600	17.2	16.3	43.0
624	17.2	16.3	43.0	474	11.2	13.7	71.0	624	17.2	16.3	43.0
648	17.2	16.3	43.0	492	11.2	13.7	71.0	648	17.2	16.3	43.0
672	17.2	16.3	43.0	510	11.2	13.7	71.0	672	17.2	16.3	43.0
696	17.2	16.3	43.0	528	11.2	13.7	71.0	696	17.2	16.3	43.0
720	17.2	16.3	43.0	546	11.2	13.7	71.0	720	17.2	16.3	43.0
744	17.2	16.3	43.0	564	11.2	13.7	71.0	744	17.2	16.3	43.0
768	17.2	16.3	43.0	582	11.2	13.7	71.0	768	17.2	16.3	43.0
792	17.2	16.3	43.0	600	11.2	13.7	71.0	792	17.2	16.3	43.0
816	17.2	16.3	43.0	618	11.2	13.7	71.0	816	17.2	16.3	43.0
840	17.2	16.3	43.0	636	11.2	13.7	71.0	840	17.2	16.3	43.0
864	17.2	16.3	43.0	654	11.2	13.7	71.0	864	17.2	16.3	43.0
888	17.2	16.3	43.0	672	11.2	13.7	71.0	888	17.2	16.3	43.0
912	17.2	16.3	43.0	690	11.2	13.7	71.0	912	17.2	16.3	43.0
936	17.2	16.3	43.0	708	11.2	13.7	71.0	936	17.2	16.3	43.0
960	17.2	16.3	43.0	726	11.2	13.7	71.0	960	17.2	16.3	43.0
984	17.2	16.3	43.0	744	11.2	13.7	71.0	984	17.2	16.3	43.0
1008	17.2	16.3	43.0	762	11.2	13.7	71.0	1008	17.2	16.3	43.0
1032	17.2	16.3	43.0	780	11.2	13.7	71.0	1032	17.2	16.3	43.0
1056	17.2	16.3	43.0	798	11.2	13.7	71.0	1056	17.2	16.3	43.0
1080	17.2	16.3	43.0	816	11.2	13.7	71.0	1080	17.2	16.3	43.0
1104	17.2	16.3	43.0	834	11.2	13.7	71.0	1104	17.2	16.3	43.0
1128	17.2	16.3	43.0	852	11.2	13.7	71.0	1128	17.2	16.3	43.0
1152	17.2	16.3	43.0	870	11.2	13.7	71.0	1152	17.2	16.3	43.0
1176	17.2	16.3	43.0	888	11.2	13.7	71.0	1176	17.2	16.3	43.0
1200	17.2	16.3	43.0	906	11.2	13.7	71.0	1200	17.2	16.3	43.0
1224	17.2	16.3	43.0	924	11.2	13.7	71.0	1224	17.2	16.3	43.0
1248	17.2	16.3	43.0	942	11.2	13.7	71.0	1248	17.2	16.3	43.0
1272	17.2	16.3	43.0	960	11.2	13.7	71.0	1272	17.2	16.3	43.0
1296	17.2	16.3	43.0	978	11.2	13.7	71.0	1296	17.2	16.3	43.0
1320	17.2	16.3	43.0	996	11.2	13.7	71.0	1320	17.2	16.3	43.0
1344	17.2	16.3	43.0	1014	11.2	13.7	71.0	1344	17.2	16.3	43.0
1368	17.2	16.3	43.0	1032	11.2	13.7	71.0	1368	17.2	16.3	43.0
1392	17.2	16.3	43.0	1050	11.2	13.7	71.0	1392	17.2	16.3	43.0
1416	17.2	16.3	43.0	1068	11.2	13.7	71.0	1416	17.2	16.3	43.0
1440	17.2	16.3	43.0	1086	11.2	13.7	71.0	1440	17.2	16.3	43.0
1464	17.2	16.3	43.0	1104	11.2	13.7	71.0	1464	17.2	16.3	43.0
1488	17.2	16.3	43.0	1122	11.2	13.7	71.0	1488	17.2	16.3	43.0
1512	17.2	16.3	43.0	1140	11.2	13.7	71.0	1512	17.2	16.3	43.0
1536	17.2	16.3	43.0	1158	11.2	13.7	71.0	1536	17.2	16.3	43.0
1560	17.2	16.3	43.0	1176	11.2	13.7	71.0	1560	17.2	16.3	43.0
1584	17.2	16.3	43.0	1194	11.2	13.7	71.0	1584	17.2	16.3	43.0
1608	17.2	16.3	43.0	1212	11.2	13.7	71.0	1608	17.2	16.3	43.0
1632	17.2	16.3	43.0	1230	11.2	13.7	71.0	1632	17.2	16.3	43.0
1656	17.2	16.3	43.0	1248	11.2	13.7	71.0	1656	17.2	16.3	43.0
1680	17.2	16.3	43.0	1266	11.2	13.7	71.0	1680	17.2	16.3	43.0
1704	17.2	16.3	43.0	1284	11.2	13.7	71.0	1704	17.2	16.3	43.0
1728	17.2	16.3	43.0	1302	11.2	13.7	71.0	1728	17.2	16.3	43.0
1752	17.2	16.3	43.0	1320	11.2	13.7	71.0	1752	17.2	16.3	43.0
1776	17.2	16.3	43.0	1338	11.2	13.7	71.0	1776	17.2	16.3	43.0
1800	17.2	16.3	43.0	1356	11.2	13.7	71.0	1800	17.2	16.3	43.0
1824	17.2	16.3	43.0	1374	11.2	13.7	71.0	1824	17.2	16.3	43.0
1848	17.2	16.3	43.0	1392	11.2	13.7	71.0	1848	17.2	16.3	43.0
1872	17.2	16.3	43.0	1410	11.2	13.7	71.0	1872	17.2	16.3	43.0
1896	17.2	16.3	43.0	1428	11.2	13.7	71.0	1896	17.2	16.3	43.0
1920	17.2	16.3	43.0	1446	11.2	13.7	71.0	1920	17.2	16.3	43.0
1944	17.2	16.3	43.0	1464	11.2	13.7	71.0	1944	17.2	16.3	43.0
1968	17.2	16.3	43.0	1482	11.2	13.7	71.0	1968	17.2	16.3	43.0
1992	17.2	16.3	43.0	1500	11.2	13.7	71.0	1992	17.2	16.3	43.0
2016	17.2	16.3	43.0	1518	11.2	13.7	71.0	2016	17.2	16.3	43.0
2040	17.2	16.3	43.0	1536	11.2	13.7	71.0	2040	17.2	16.3	43.0
2064	17.2	16.3	43.0	1554	11.2	13.7	71.0	2064	17.2	16.3	43.0
2088	17.2	16.3	43.0	1572	11.2	13.7	71.0	2088	17.2	16.3	43.0
2112	17.2	16.3	43.0	1590	11.2	13.7	71.0	2112	17.2	16.3	43.0
2136	17.2	16.3	43.0	1608	11.2	13.7	71.0	2136	17.2	16.3	43.0
2160	17.2	16.3	43.0	1626	11.2	13.7	71.0	2160	17.2	16.3	43.0
2184	17.2	16.3	43.0	1644	11.2	13.7	71.0	2184	17.2	16.3	43.0
2208	17.2	16.3	43.0	1662	11.2	13.7	71.0	2208	17.2	16.3	43.0
2232	17.2	16.3	43.0	1680	11.2	13.7	71.0	2232	17.2	16.3	43.0
2256	17.2	16.3	43.0	1698	11.2	13.7	71.0	2256	17.2	16.3	43.0
2280	17.2	16.3	43.0	1716	11.2	13.7	71.0	2280	17.2	16.3	43.0
2304	17.2	16.3	43.0	1734	11.2	13.7	71.0	2304	17.2	16.3	43.0
2328	17.2	16.3	43.0	1752	11.2	13.7	71.0	2328	17.2	16.3	43.0
2352	17.2	16.3	43.0	1770	11.2	13.7	71.0	2352	17.2	16.3	43.0
2376	17.2	16.3	43.0	1788	11.2	13.7	71.0	2376	17.2	16.3	43.0
2400	17.2	16.3	43.0	1806	11.2	13.7	71.0	2400	17.2	16.3	43.0
2424	17.2	16.3	43.0	1824	11.2	13.7	71.0	2424	17.2	16.3	43.0
2448	17.2	16.3	43.0	1842	11.2	13.7	71.0	2448	17.2	16.3	43.0
2472	17.2	16.3	43.0	1860	11.2	13.7	71.0	2472	17.2	16.3	43.0
2496	17.2	16.3	43.0	1878	11.2	13.7	71.0	2496	17.2	16.3	43.0
2520	17.2	16.3	43.0	1896	11.2	13.7	71.0	2520	17.2	16.3	43.0
2544	17.2	16.3	43.0	1914	11.2	13.7	71.0	2544	17.2	16.3	43.0
2568	17.2	16.3	43.0	1932	11.2	13.7	71.0	2568	17.2	16.3	43.0
2592	17.2	16.3	43.0	1950	11.2	13.7	71.0	2592	17.2	16.3	43.0
2616	17.2	16.3	43.0	1968	11.2	13.7	71.0	2616	17.2	16.3	43.0

TABLE 2--PEDESTRIAN WIND VELOCITIES AND TURBULENCE INTENSITIES
INTERNATIONAL PLACE PHASE I WITH EXISTING OFF-RAMP

LOCATION 49			LOCATION 50		
WIND AZIMUTH	U/MS/UMF (PERCENT)	U/MS/UMF (PERCENT)	WIND AZIMUTH	U/MS/UMF (PERCENT)	U/MS/UMF (PERCENT)
00	24	07	00	01	07
00	46	11	05	05	05
00	46	11	25	00	00
00	33	11	45	00	00
00	44	09	60	00	00
00	44	09	75	00	00
00	44	09	90	00	00
00	44	09	105	00	00
00	44	09	120	00	00
00	44	09	135	00	00
00	44	09	150	00	00
00	44	09	165	00	00
00	44	09	180	00	00
00	44	09	195	00	00
00	44	09	210	00	00
00	44	09	225	00	00
00	44	09	240	00	00
00	44	09	255	00	00
00	44	09	270	00	00
00	44	09	285	00	00
00	44	09	300	00	00
00	44	09	315	00	00
00	44	09	330	00	00
00	44	09	345	00	00
00	44	09	360	00	00
00	44	09	375	00	00
00	44	09	390	00	00
00	44	09	405	00	00
00	44	09	420	00	00
00	44	09	435	00	00
00	44	09	450	00	00
00	44	09	465	00	00
00	44	09	480	00	00
00	44	09	495	00	00
00	44	09	510	00	00
00	44	09	525	00	00
00	44	09	540	00	00
00	44	09	555	00	00
00	44	09	570	00	00
00	44	09	585	00	00
00	44	09	600	00	00
00	44	09	615	00	00
00	44	09	630	00	00
00	44	09	645	00	00
00	44	09	660	00	00
00	44	09	675	00	00
00	44	09	690	00	00
00	44	09	705	00	00
00	44	09	720	00	00
00	44	09	735	00	00
00	44	09	750	00	00
00	44	09	765	00	00
00	44	09	780	00	00
00	44	09	795	00	00
00	44	09	810	00	00
00	44	09	825	00	00
00	44	09	840	00	00
00	44	09	855	00	00
00	44	09	870	00	00
00	44	09	885	00	00
00	44	09	900	00	00
00	44	09	915	00	00
00	44	09	930	00	00
00	44	09	945	00	00
00	44	09	960	00	00
00	44	09	975	00	00
00	44	09	990	00	00
00	44	09	1005	00	00
00	44	09	1020	00	00
00	44	09	1035	00	00
00	44	09	1050	00	00
00	44	09	1065	00	00
00	44	09	1080	00	00
00	44	09	1095	00	00
00	44	09	1110	00	00
00	44	09	1125	00	00
00	44	09	1140	00	00
00	44	09	1155	00	00
00	44	09	1170	00	00
00	44	09	1185	00	00
00	44	09	1200	00	00
00	44	09	1215	00	00
00	44	09	1230	00	00
00	44	09	1245	00	00
00	44	09	1260	00	00
00	44	09	1275	00	00
00	44	09	1290	00	00
00	44	09	1305	00	00
00	44	09	1320	00	00
00	44	09	1335	00	00
00	44	09	1350	00	00
00	44	09	1365	00	00
00	44	09	1380	00	00
00	44	09	1395	00	00
00	44	09	1410	00	00
00	44	09	1425	00	00
00	44	09	1440	00	00
00	44	09	1455	00	00
00	44	09	1470	00	00
00	44	09	1485	00	00
00	44	09	1500	00	00
00	44	09	1515	00	00
00	44	09	1530	00	00
00	44	09	1545	00	00
00	44	09	1560	00	00
00	44	09	1575	00	00
00	44	09	1590	00	00
00	44	09	1605	00	00
00	44	09	1620	00	00
00	44	09	1635	00	00
00	44	09	1650	00	00
00	44	09	1665	00	00
00	44	09	1680	00	00
00	44	09	1695	00	00
00	44	09	1710	00	00
00	44	09	1725	00	00
00	44	09	1740	00	00
00	44	09	1755	00	00
00	44	09	1770	00	00
00	44	09	1785	00	00
00	44	09	1800	00	00
00	44	09	1815	00	00
00	44	09	1830	00	00
00	44	09	1845	00	00
00	44	09	1860	00	00
00	44	09	1875	00	00
00	44	09	1890	00	00
00	44	09	1905	00	00
00	44	09	1920	00	00
00	44	09	1935	00	00
00	44	09	1950	00	00
00	44	09	1965	00	00
00	44	09	1980	00	00
00	44	09	1995	00	00
00	44	09	2010	00	00
00	44	09	2025	00	00
00	44	09	2040	00	00
00	44	09	2055	00	00
00	44	09	2070	00	00
00	44	09	2085	00	00
00	44	09	2100	00	00
00	44	09	2115	00	00
00	44	09	2130	00	00
00	44	09	2145	00	00
00	44	09	2160	00	00
00	44	09	2175	00	00
00	44	09	2190	00	00
00	44	09	2205	00	00
00	44	09	2220	00	00
00	44	09	2235	00	00
00	44	09	2250	00	00
00	44	09	2265	00	00
00	44	09	2280	00	00
00	44	09	2295	00	00
00	44	09	2310	00	00
00	44	09	2325	00	00
00	44	09	2340	00	00
00	44	09	2355	00	00
00	44	09	2370	00	00
00	44	09	2385	00	00
00	44	09	2400	00	00
00	44	09	2415	00	00
00	44	09	2430	00	00
00	44	09	2445	00	00
00	44	09	2460	00	00
00	44	09	2475	00	00
00	44	09	2490	00	00
00	44	09	2505	00	00
00	44	09	2520	00	00
00	44	09	2535	00	00
00	44	09	2550	00	00
00	44	09	2565	00	00
00	44	09	2580	00	00
00	44	09	2595	00	00
00	44	09	2610	00	00
00	44	09	2625	00	00
00	44	09	2640	00	00
00	44	09	2655	00	00
00	44	09	2670	00	00
00	44	09	2685	00	00
00	44	09	2700	00	00
00	44	09	2715	00	00
00	44	09	2730	00	00
00	44	09	2745	00	00
00	44	09	2760	00	00
00	44	09	2775	00	00
00	44	09	2790	00	00
00	44	09	2805	00	00
00	44	09	2820	00	00
00	44	09	2835	00	00
00	44	09	2850	00	00
00	44	09	2865	00	00
00	44	09	2880	00	00
00	44	09	2895	00	00
00	44	09	2910	00	00
00	44	09	2925	00	00
00	44	09	2940	00	00
00	44	09	2955	00	00
00	44	09	2970	00	00
00	44	09	2985	00	00
00	44	09	3000	00	00
00	44	09	3015	00	00
00	44	09	3030	00	00
00	44	09	3045	00	00
00	44	09	3060	00	00
00	44	09	3075	00	00
00	44	09	3090	00	00
00	44	09	3105	00	00
00	44	09	3120	00	00
00	44	09	3135	00	00
00	44	09	3150	00	00
00	44	09	3165	00	00
00	44	09	3180	00	00
00	44	09	3195	00	00
00	44	09	3210	00	00
00	44	09	3225	00	00
00	44	09	3240	00	00
00	44	09	3255	00	00
00	44	09	3270	00	00
00	44	09	3285	00	00
00	44	09	3300	00	00
00	44	09	3315	00	00
00	44	09	3330	00	00
00	44	09	3345	00	00
00	44	09	3360	00	00
00	44	09	3375	00	00
00	44	09	3390	00	00
00	44	09	3405	00	00
00	44	09	3420	00	00
00	44	09	3435	00	00
00	44	09	3450	00	00
00	44	09	3465	00	00
00	44	09	3480	00	00
00	44	09	3495	00	00
00	44	09	3510	00	00
00	44	09	3525	00	00
00	44	09	3540	00	00
00	44	09	3555	00	00
00	44	09	3570	00	00
00	44	09	3585	00	00
00	44	09	3600	00	00
00	44	09	3615	00	00
00	44	09	3630	00	00
00	44	09	3645		

TABLE 2--PEDESTRIAN WIND VELOCITIES AND TURBULENCE INTENSITIES
INTERNATIONAL PLACE PHASE II WITH NEW OFF-RAMP

LOCATION	5	6
LOCATION	WIND AZIMUTH	WIND AZIMUTH
UMERG/UMINF (PERCENT)	UMERG/UMINF (PERCENT)	UMERG/UMINF (PERCENT)
UMERG+1.5 UMRG/UMINF (PERCENT)	UMERG+1.5 UMRG/UMINF (PERCENT)	UMERG+1.5 UMRG/UMINF (PERCENT)

[illegible]

[illegible]

TABLE 2--PEDESTRIAN WIND VELOCITIES AND TURBULENCE INTENSITIES
INTERNATIONAL PLACE PHASE II WITH NEW OFF-RAMP

LOCATION 13					
WIND AZIMUTH	U _{MEAN} /U _{INF} (PERCENT)	U _{MS} /U _{INF} (PERCENT)	U _{MEAN} +1.5 U _{MS} /U _{INF} (PERCENT)	WIND AZIMUTH	U _{MEAN} /U _{INF} (PERCENT)
00	37	10	22	00	17
05	44	11	25	05	22
10	24	10	22	10	17
15	24	10	22	15	17
20	24	10	22	20	17
25	24	10	22	25	17
30	24	10	22	30	17
35	24	10	22	35	17
40	24	10	22	40	17
45	24	10	22	45	17
50	24	10	22	50	17
55	24	10	22	55	17
60	24	10	22	60	17
65	24	10	22	65	17
70	24	10	22	70	17
75	24	10	22	75	17
80	24	10	22	80	17
85	24	10	22	85	17
90	24	10	22	90	17
95	24	10	22	95	17
100	24	10	22	100	17
105	24	10	22	105	17
110	24	10	22	110	17
115	24	10	22	115	17
120	24	10	22	120	17
125	24	10	22	125	17
130	24	10	22	130	17
135	24	10	22	135	17
140	24	10	22	140	17
145	24	10	22	145	17
150	24	10	22	150	17
155	24	10	22	155	17
160	24	10	22	160	17
165	24	10	22	165	17
170	24	10	22	170	17
175	24	10	22	175	17
180	24	10	22	180	17
185	24	10	22	185	17
190	24	10	22	190	17
195	24	10	22	195	17
200	24	10	22	200	17
205	24	10	22	205	17
210	24	10	22	210	17
215	24	10	22	215	17
220	24	10	22	220	17
225	24	10	22	225	17
230	24	10	22	230	17
235	24	10	22	235	17
240	24	10	22	240	17
245	24	10	22	245	17
250	24	10	22	250	17
255	24	10	22	255	17
260	24	10	22	260	17
265	24	10	22	265	17
270	24	10	22	270	17
275	24	10	22	275	17
280	24	10	22	280	17
285	24	10	22	285	17
290	24	10	22	290	17
295	24	10	22	295	17
300	24	10	22	300	17
305	24	10	22	305	17
310	24	10	22	310	17
315	24	10	22	315	17
320	24	10	22	320	17
325	24	10	22	325	17
330	24	10	22	330	17
335	24	10	22	335	17
340	24	10	22	340	17
345	24	10	22	345	17
350	24	10	22	350	17
355	24	10	22	355	17
360	24	10	22	360	17
365	24	10	22	365	17
370	24	10	22	370	17
375	24	10	22	375	17
380	24	10	22	380	17
385	24	10	22	385	17
390	24	10	22	390	17
395	24	10	22	395	17
400	24	10	22	400	17
405	24	10	22	405	17
410	24	10	22	410	17
415	24	10	22	415	17
420	24	10	22	420	17
425	24	10	22	425	17
430	24	10	22	430	17
435	24	10	22	435	17
440	24	10	22	440	17
445	24	10	22	445	17
450	24	10	22	450	17
455	24	10	22	455	17
460	24	10	22	460	17
465	24	10	22	465	17
470	24	10	22	470	17
475	24	10	22	475	17
480	24	10	22	480	17
485	24	10	22	485	17
490	24	10	22	490	17
495	24	10	22	495	17
500	24	10	22	500	17
505	24	10	22	505	17
510	24	10	22	510	17
515	24	10	22	515	17
520	24	10	22	520	17
525	24	10	22	525	17
530	24	10	22	530	17
535	24	10	22	535	17
540	24	10	22	540	17
545	24	10	22	545	17
550	24	10	22	550	17
555	24	10	22	555	17
560	24	10	22	560	17
565	24	10	22	565	17
570	24	10	22	570	17
575	24	10	22	575	17
580	24	10	22	580	17
585	24	10	22	585	17
590	24	10	22	590	17
595	24	10	22	595	17
600	24	10	22	600	17
605	24	10	22	605	17
610	24	10	22	610	17
615	24	10	22	615	17
620	24	10	22	620	17
625	24	10	22	625	17
630	24	10	22	630	17
635	24	10	22	635	17
640	24	10	22	640	17
645	24	10	22	645	17
650	24	10	22	650	17
655	24	10	22	655	17
660	24	10	22	660	17
665	24	10	22	665	17
670	24	10	22	670	17
675	24	10	22	675	17
680	24	10	22	680	17
685	24	10	22	685	17
690	24	10	22	690	17
695	24	10	22	695	17
700	24	10	22	700	17
705	24	10	22	705	17
710	24	10	22	710	17
715	24	10	22	715	17
720	24	10	22	720	17
725	24	10	22	725	17
730	24	10	22	730	17
735	24	10	22	735	17
740	24	10	22	740	17
745	24	10	22	745	17
750	24	10	22	750	17
755	24	10	22	755	17
760	24	10	22	760	17
765	24	10	22	765	17
770	24	10	22	770	17
775	24	10	22	775	17
780	24	10	22	780	17
785	24	10	22	785	17
790	24	10	22	790	17
795	24	10	22	795	17
800	24	10	22	800	17
805	24	10	22	805	17
810	24	10	22	810	17
815	24	10	22	815	17
820	24	10	22	820	17
825	24	10	22	825	17
830	24	10	22	830	17
835	24	10	22	835	17
840	24	10	22	840	17
845	24	10	22	845	17
850	24	10	22	850	17
855	24	10	22	855	17
860	24	10	22	860	17
865	24	10	22	865	17
870	24	10	22	870	17
875	24	10	22	875	17
880	24	10	22	880	17
885	24	10	22	885	17
890	24	10	22	890	17
895	24	10	22	895	17
900	24	10	22	900	17
905	24	10	22	905	17
910	24	10	22	910	17
915	24	10	22	915	17
920	24	10	22	920	17
925	24	10	22	925	17
930	24	10	22	930	17
935	24	10	22	935	17
940	24	10	22	940	17
945	24	10	22	945	17
950	24	10	22	950	17
955	24	10	22	955	17
960	24	10	22	960	17
965	24	10	22	965	17
970	24	10	22	970	17
975	24	10	22	975	17
980	24	10	22	980	17
985	24	10	22	985	17
990	24	10	22	990	17
995	24	10	22	995	17
1000	24	10	22	1000	17

TABLE 2--PEDESTRIAN WIND VELOCITIES AND TURBULENCE INTENSITIES
INTERNATIONAL PLACE PHASE II WITH NEW OFF-PUMP

LOCATION 17					LOCATION 18				
WIND AZIMUTH	UMEAN/UINF (PERCENT)	URMS/UINF (PERCENT)	UMEAN+1.5URMS/UINF (PERCENT)	WIND AZIMUTH	UMEAN/UINF (PERCENT)	URMS/UINF (PERCENT)	UMEAN+1.5URMS/UINF (PERCENT)		
00	10	10	27	00	20	11	21	2	
09	10	10	27	09	20	11	21	3	
24	10	10	27	24	20	12	22	4	
45	10	10	27	45	20	12	22	4	
67	10	10	27	67	20	13	23	2	
89	10	10	27	89	20	14	24	3	
112	10	10	27	112	20	14	24	3	
135	10	10	27	135	20	15	25	2	
157	10	10	27	157	20	16	26	2	
180	10	10	27	180	20	16	26	2	
202	10	10	27	202	20	17	27	2	
224	10	10	27	224	20	17	27	2	
247	10	10	27	247	20	18	28	2	
269	10	10	27	269	20	18	28	2	
292	10	10	27	292	20	19	29	2	
315	10	10	27	315	20	19	29	2	
337	10	10	27	337	20	20	30	2	
LOCATION 19					LOCATION 20				
WIND AZIMUTH	UMEAN/UINF (PERCENT)	URMS/UINF (PERCENT)	UMEAN+1.5URMS/UINF (PERCENT)	WIND AZIMUTH	UMEAN/UINF (PERCENT)	URMS/UINF (PERCENT)	UMEAN+1.5URMS/UINF (PERCENT)		
00	24	10	36	00	23	00	37	4	
22	22	12	33	22	23	00	37	3	
44	22	12	33	44	23	00	37	3	
67	22	12	33	67	23	00	37	3	
89	22	12	33	89	23	00	37	3	
112	22	12	33	112	23	00	37	3	
135	22	12	33	135	23	00	37	3	
157	22	12	33	157	23	00	37	3	
180	22	12	33	180	23	00	37	3	
202	22	12	33	202	23	00	37	3	
224	22	12	33	224	23	00	37	3	
247	22	12	33	247	23	00	37	3	
269	22	12	33	269	23	00	37	3	
292	22	12	33	292	23	00	37	3	
315	22	12	33	315	23	00	37	3	
337	22	12	33	337	23	00	37	3	

TABLE 2--PEDESTRIAN WIND VELOCITIES AND TURBULENCE INTENSITIES
INTERNATIONAL PLACE PHASE II WITH NEW OFF-RAMP

[illegible]

TABLE 2--PEDESTRIAN WIND VELOCITIES AND TURBULENCE INTENSITIES
INTERNATIONAL PLACE PHASE II WITH NEW OFF-PUMP

LOCATION 29					LOCATION 30				
WIND AZIMUTH	U _{REF} /U _{INF} (PERCENT)	U _{REF} /U _{INF} (PERCENT)	U _{REF} +1.5*U _{REF} /U _{INF} (PERCENT)	WIND AZIMUTH	U _{REF} /U _{INF} (PERCENT)	U _{REF} /U _{INF} (PERCENT)	U _{REF} +1.5*U _{REF} /U _{INF} (PERCENT)	WIND AZIMUTH	U _{REF} /U _{INF} (PERCENT)
00	322	322	72	00	21	7	31	00	29
22	322	322	67	22	23	12	48	22	23
45	322	322	72	45	23	18	38	45	23
67	322	322	72	67	23	26	46	67	23
90	322	322	72	90	26	9	40	90	26
112	322	322	72	112	44	3	63	112	44
137	322	322	72	137	60	7	61	137	60
160	322	322	72	160	74	1	53	160	74
180	322	322	72	180	74	2	53	180	74
202	322	322	72	202	23	2	53	202	23
225	322	322	72	225	23	16	48	225	23
247	322	322	72	247	24	9	40	247	24
269	322	322	72	269	27	2	53	269	27
292	322	322	72	292	27	16	48	292	27
317	322	322	72	317	28	2	53	317	28
340	322	322	72	340	28	12	37	340	28
LOCATION 31					LOCATION 32				
WIND AZIMUTH	U _{REF} /U _{INF} (PERCENT)	U _{REF} /U _{INF} (PERCENT)	U _{REF} +1.5*U _{REF} /U _{INF} (PERCENT)	WIND AZIMUTH	U _{REF} /U _{INF} (PERCENT)	U _{REF} /U _{INF} (PERCENT)	U _{REF} +1.5*U _{REF} /U _{INF} (PERCENT)	WIND AZIMUTH	U _{REF} /U _{INF} (PERCENT)
00	322	322	43	00	33	4	69	00	20
22	322	322	43	22	33	11	49	22	11
45	322	322	43	45	33	22	49	45	18
67	322	322	43	67	33	22	49	67	22
90	322	322	43	90	33	22	49	90	22
112	322	322	43	112	33	22	49	112	22
137	322	322	43	137	33	22	49	137	22
160	322	322	43	160	33	22	49	160	22
180	322	322	43	180	33	22	49	180	22
202	322	322	43	202	33	22	49	202	22
225	322	322	43	225	33	22	49	225	22
247	322	322	43	247	33	22	49	247	22
269	322	322	43	269	33	22	49	269	22
292	322	322	43	292	33	22	49	292	22
317	322	322	43	317	33	22	49	317	22
340	322	322	43	340	33	22	49	340	22

TABLE 2--PEDESTRIAN WIND VELOCITIES AND TURBULENCE INTENSITIES
INTERNATIONAL PLACE PHASE II WITH NEW OFF-RAMP

LOCATION 32					LOCATION 34					LOCATION 35					LOCATION 36				
WIND AZIMUTH	U _{MEAN} /U _{INF} (PERCENT)	U _{PM} /U _{INF} (PERCENT)	U _{MEAN} +1.5*U _{PM} /U _{INF} (PERCENT)	WIND AZIMUTH	U _{MEAN} /U _{INF} (PERCENT)	U _{PM} /U _{INF} (PERCENT)	U _{MEAN} +1.5*U _{PM} /U _{INF} (PERCENT)	WIND AZIMUTH	U _{MEAN} /U _{INF} (PERCENT)	U _{PM} /U _{INF} (PERCENT)	U _{MEAN} +1.5*U _{PM} /U _{INF} (PERCENT)	WIND AZIMUTH	U _{MEAN} /U _{INF} (PERCENT)	U _{PM} /U _{INF} (PERCENT)	U _{MEAN} +1.5*U _{PM} /U _{INF} (PERCENT)	WIND AZIMUTH	U _{MEAN} /U _{INF} (PERCENT)	U _{PM} /U _{INF} (PERCENT)	U _{MEAN} +1.5*U _{PM} /U _{INF} (PERCENT)
00	51	11	51	00	21	10	21	00	29	12	29	00	29	12	29	00	21	10	21
06	51	11	51	06	21	10	21	06	29	12	29	06	29	12	29	06	21	10	21
12	51	11	51	12	21	10	21	12	29	12	29	12	29	12	29	12	21	10	21
18	51	11	51	18	21	10	21	18	29	12	29	18	29	12	29	18	21	10	21
24	51	11	51	24	21	10	21	24	29	12	29	24	29	12	29	24	21	10	21
30	51	11	51	30	21	10	21	30	29	12	29	30	29	12	29	30	21	10	21
36	51	11	51	36	21	10	21	36	29	12	29	36	29	12	29	36	21	10	21
42	51	11	51	42	21	10	21	42	29	12	29	42	29	12	29	42	21	10	21
48	51	11	51	48	21	10	21	48	29	12	29	48	29	12	29	48	21	10	21
54	51	11	51	54	21	10	21	54	29	12	29	54	29	12	29	54	21	10	21
60	51	11	51	60	21	10	21	60	29	12	29	60	29	12	29	60	21	10	21
66	51	11	51	66	21	10	21	66	29	12	29	66	29	12	29	66	21	10	21
72	51	11	51	72	21	10	21	72	29	12	29	72	29	12	29	72	21	10	21
78	51	11	51	78	21	10	21	78	29	12	29	78	29	12	29	78	21	10	21
84	51	11	51	84	21	10	21	84	29	12	29	84	29	12	29	84	21	10	21
90	51	11	51	90	21	10	21	90	29	12	29	90	29	12	29	90	21	10	21
96	51	11	51	96	21	10	21	96	29	12	29	96	29	12	29	96	21	10	21
102	51	11	51	102	21	10	21	102	29	12	29	102	29	12	29	102	21	10	21
108	51	11	51	108	21	10	21	108	29	12	29	108	29	12	29	108	21	10	21
114	51	11	51	114	21	10	21	114	29	12	29	114	29	12	29	114	21	10	21
120	51	11	51	120	21	10	21	120	29	12	29	120	29	12	29	120	21	10	21
126	51	11	51	126	21	10	21	126	29	12	29	126	29	12	29	126	21	10	21
132	51	11	51	132	21	10	21	132	29	12	29	132	29	12	29	132	21	10	21
138	51	11	51	138	21	10	21	138	29	12	29	138	29	12	29	138	21	10	21
144	51	11	51	144	21	10	21	144	29	12	29	144	29	12	29	144	21	10	21
150	51	11	51	150	21	10	21	150	29	12	29	150	29	12	29	150	21	10	21
156	51	11	51	156	21	10	21	156	29	12	29	156	29	12	29	156	21	10	21
162	51	11	51	162	21	10	21	162	29	12	29	162	29	12	29	162	21	10	21
168	51	11	51	168	21	10	21	168	29	12	29	168	29	12	29	168	21	10	21
174	51	11	51	174	21	10	21	174	29	12	29	174	29	12	29	174	21	10	21
180	51	11	51	180	21	10	21	180	29	12	29	180	29	12	29	180	21	10	21
186	51	11	51	186	21	10	21	186	29	12	29	186	29	12	29	186	21	10	21
192	51	11	51	192	21	10	21	192	29	12	29	192	29	12	29	192	21	10	21
198	51	11	51	198	21	10	21	198	29	12	29	198	29	12	29	198	21	10	21
204	51	11	51	204	21	10	21	204	29	12	29	204	29	12	29	204	21	10	21
210	51	11	51	210	21	10	21	210	29	12	29	210	29	12	29	210	21	10	21
216	51	11	51	216	21	10	21	216	29	12	29	216	29	12	29	216	21	10	21
222	51	11	51	222	21	10	21	222	29	12	29	222	29	12	29	222	21	10	21
228	51	11	51	228	21	10	21	228	29	12	29	228	29	12	29	228	21	10	21
234	51	11	51	234	21	10	21	234	29	12	29	234	29	12	29	234	21	10	21
240	51	11	51	240	21	10	21	240	29	12	29	240	29	12	29	240	21	10	21
246	51	11	51	246	21	10	21	246	29	12	29	246	29	12	29	246	21	10	21
252	51	11	51	252	21	10	21	252	29	12	29	252	29	12	29	252	21	10	21
258	51	11	51	258	21	10	21	258	29	12	29	258	29	12	29	258	21	10	21
264	51	11	51	264	21	10	21	264	29	12	29	264	29	12	29	264	21	10	21
270	51	11	51	270	21	10	21	270	29	12	29	270	29	12	29	270	21	10	21
276	51	11	51	276	21	10	21	276	29	12	29	276	29	12	29	276	21	10	21
282	51	11	51	282	21	10	21	282	29	12	29	282	29	12	29	282	21	10	21
288	51	11	51	288	21	10	21	288	29	12	29	288	29	12	29	288	21	10	21
294	51	11	51	294	21	10	21	294	29	12	29	294	29	12	29	294	21	10	21
300	51	11	51	300	21	10	21	300	29	12	29	300	29	12	29	300	21	10	21
306	51	11	51	306	21	10	21	306	29	12	29	306	29	12	29	306	21	10	21
312	51	11	51	312	21	10	21	312	29	12	29	312	29	12	29	312	21	10	21
318	51	11	51	318	21	10	21	318	29	12	29	318	29	12	29	318	21	10	21
324	51	11	51	324	21	10	21	324	29	12	29	324	29	12	29	324	21	10	21
330	51	11	51	330	21	10	21	330	29	12	29	330	29	12	29	330	21	10	21
336	51	11	51	336	21	10	21	336	29	12	29	336	29	12	29	336	21	10	21
342	51	11	51	342	21	10	21	342	29	12	29	342	29	12	29	342	21	10	21
348	51	11	51	348	21	10	21	348	29	12	29	348	29	12	29	348	21	10	21
354	51	11	51	354	21	10	21	354	29	12	29	354	29	12	29	354	21	10	21
360	51	11	51	360	21	10	21	360	29	12	29	360	29	12	29	360	21	10	21

TABLE 2--PEDESTRIAN WIND VELOCITIES AND TURBULENCE INTENSITIES
INTERNATIONAL PLACE PHASE 11 WITH NEW OFF RAMP

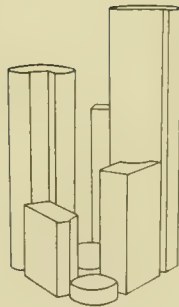
LOCATION 27						LOCATION 38						LOCATION 40					
WIND AZIMUTH	UMEAN/UINF (PERCENT)	URMS/UINF (PERCENT)	UMEAN+1.5URMS/UINF (PERCENT)	WIND AZIMUTH	UMEAN/UINF (PERCENT)	URMS/UINF (PERCENT)	UMEAN+1.5URMS/UINF (PERCENT)	WIND AZIMUTH	UMEAN/UINF (PERCENT)	URMS/UINF (PERCENT)	UMEAN+1.5URMS/UINF (PERCENT)	WIND AZIMUTH	UMEAN/UINF (PERCENT)	URMS/UINF (PERCENT)	UMEAN+1.5URMS/UINF (PERCENT)	WIND AZIMUTH	UMEAN/UINF (PERCENT)
00	20	12	43	00	22	12	43	00	34	19	57	00	34	19	57	00	34
05	22	13	45	05	23	13	46	05	25	14	48	05	26	15	50	05	27
10	23	14	47	10	24	14	48	10	26	15	50	10	28	16	52	10	29
15	24	15	49	15	25	15	50	15	27	16	52	15	29	17	54	15	31
20	25	16	51	20	26	16	52	20	28	17	54	20	30	18	56	20	32
25	26	17	53	25	27	17	54	25	29	18	56	25	31	19	58	25	33
30	27	18	55	30	28	18	56	30	30	19	58	30	32	20	60	30	34
35	28	19	57	35	29	19	58	35	31	20	60	35	33	21	62	35	35
40	29	20	59	40	30	20	60	40	32	21	62	40	34	22	64	40	36
45	30	21	61	45	31	21	62	45	33	22	64	45	35	23	66	45	37
50	31	22	63	50	32	22	64	50	34	23	66	50	36	24	68	50	38
55	32	23	65	55	33	23	66	55	35	24	68	55	37	25	70	55	39
60	33	24	67	60	34	24	68	60	36	25	70	60	38	26	72	60	40
65	34	25	69	65	35	25	70	65	37	26	72	65	39	27	74	65	41
70	35	26	71	70	36	26	72	70	38	27	74	70	40	28	76	70	42
75	36	27	73	75	37	27	74	75	39	28	76	75	41	29	78	75	43
80	37	28	75	80	38	28	76	80	40	29	78	80	42	30	80	80	44
85	38	29	77	85	39	29	78	85	41	30	80	85	43	31	82	85	45
90	39	30	79	90	40	30	80	90	42	31	82	90	44	32	84	90	46
95	40	31	81	95	41	31	82	95	43	32	84	95	45	33	86	95	47
100	41	32	83	100	42	32	84	100	44	33	86	100	46	34	88	100	48
105	42	33	85	105	43	33	86	105	45	34	88	105	47	35	90	105	49
110	43	34	87	110	44	34	88	110	46	35	90	110	48	36	92	110	50
115	44	35	89	115	45	35	90	115	47	36	92	115	49	37	94	115	51
120	45	36	91	120	46	36	92	120	48	37	94	120	50	38	96	120	52
125	46	37	93	125	47	37	94	125	49	38	96	125	51	39	98	125	53
130	47	38	95	130	48	38	96	130	50	39	98	130	52	40	100	130	54
135	48	39	97	135	49	39	98	135	51	40	100	135	53	41	102	135	55
140	49	40	99	140	50	40	100	140	52	41	102	140	54	42	104	140	56
145	50	41	101	145	51	41	102	145	53	42	104	145	55	43	106	145	57
150	51	42	103	150	52	42	104	150	54	43	106	150	56	44	108	150	58
155	52	43	105	155	53	43	106	155	55	44	108	155	57	45	110	155	59
160	53	44	107	160	54	44	108	160	56	45	110	160	58	46	112	160	60
165	54	45	109	165	55	45	110	165	57	46	112	165	59	47	114	165	61
170	55	46	111	170	56	46	112	170	58	47	114	170	60	48	116	170	62
175	56	47	113	175	57	47	114	175	59	48	116	175	61	49	118	175	63
180	57	48	115	180	58	48	116	180	60	49	118	180	62	50	120	180	64
185	58	49	117	185	59	49	118	185	61	50	120	185	63	51	122	185	65
190	59	50	119	190	60	50	120	190	62	51	122	190	64	52	124	190	66
195	60	51	121	195	61	51	122	195	63	52	124	195	65	53	126	195	67
200	61	52	123	200	62	52	124	200	64	53	126	200	66	54	128	200	68
205	62	53	125	205	63	53	126	205	65	54	128	205	67	55	130	205	69
210	63	54	127	210	64	54	128	210	66	55	130	210	68	56	132	210	70
215	64	55	129	215	65	55	130	215	67	56	132	215	69	57	134	215	71
220	65	56	131	220	66	56	132	220	68	57	134	220	70	58	136	220	72
225	66	57	133	225	67	57	134	225	69	58	136	225	71	59	138	225	73
230	67	58	135	230	68	58	136	230	70	59	138	230	72	60	140	230	74
235	68	59	137	235	69	59	138	235	71	60	140	235	73	61	142	235	75
240	69	60	139	240	70	60	140	240	72	61	142	240	74	62	144	240	76
245	70	61	141	245	71	61	142	245	73	62	144	245	75	63	146	245	77
250	71	62	143	250	72	62	144	250	74	63	146	250	76	64	148	250	78
255	72	63	145	255	73	63	146	255	75	64	148	255	77	65	150	255	79
260	73	64	147	260	74	64	148	260	76	65	150	260	78	66	152	260	80
265	74	65	149	265	75	65	150	265	77	66	152	265	79	67	154	265	81
270	75	66	151	270	76	66	152	270	78	67	154	270	80	68	156	270	82
275	76	67	153	275	77	67	154	275	79	68	156	275	81	69	158	275	83
280	77	68	155	280	78	68	156	280	80	69	158	280	82	70	160	280	84
285	78	69	157	285	79	69	158	285	81	70	160	285	83	71	162	285	85
290	79	70	159	290	80	70	160	290	82	71	162	290	84	72	164	290	86
295	80	71	161	295	81	71	162	295	83	72	164	295	85	73	166	295	87
300	81	72	163	300	82	72	164	300	84	73	166	300	86	74	168	300	88
305	82	73	165	305	83	73	166	305	85	74	168	305	87	75	170	305	89
310	83	74	167	310	84	74	168	310	86	75	170	310	88	76	172	310	90
315	84	75	169	315	85	75	170	315	87	76	172	315	89	77	174	315	91
320	85	76	171	320	86	76	172	320	88	77	174	320	90	78	176	320	92
325	86	77	173	325	87	77	174	325	89	78	176	325	91	79	178	325	93
330	87	78	175	330	88	78	176	330	90	79	178	330	92	80	180	330	94
335	88	79	177	335	89	79	178	335	91	80	180	335	93	81	182	335	95
340	89	80	179	340	90	80	180	340	92	81	182	340	94	82	184	340	96
345	90	81	181	345	91	81	182	345	93	82	184	345	95	83	186	345	97
350	91	82	183	350	92	82	184	350	94	83	186	350	96	84	188	350	98
355	92	83	185	355	93	83	186	355	95	84	188	355	97	85	190	355	99
360	93	84	187	360	94	84	188	360	96	85	190	360	98	86	192	360	100

[illegible]

TABLE 2--PEDESTRIAN WIND VELOCITIES AND TURBULENCE INTENSITIES
INTERNATIONAL FENCE PHASE II WITH NEW 300-9AMP

LOCATION 45					LOCATION 46					LOCATION 47				
WIND AZIMUTH	UMEN/UMF (PERCENT)	URMS/UMF (PERCENT)	UMEN+1.5URMS/UMF (PERCENT)	UMEN/UMF (PERCENT)	WIND AZIMUTH	UMEN/UMF (PERCENT)	URMS/UMF (PERCENT)	UMEN+1.5URMS/UMF (PERCENT)	UMEN/UMF (PERCENT)	WIND AZIMUTH	UMEN/UMF (PERCENT)	URMS/UMF (PERCENT)	UMEN+1.5URMS/UMF (PERCENT)	UMEN/UMF (PERCENT)
0	40	18	60	4	0	0	1	60	51	0	0	2	73	19
15	32	16	57	3	25	0	4	57	50	25	0	2	73	19
30	22	11	37	2	45	0	7	37	21	45	0	2	45	11
45	22	11	37	2	60	0	7	37	21	60	0	2	45	11
60	22	11	37	2	75	0	7	37	21	75	0	2	45	11
75	22	11	37	2	90	0	7	37	21	90	0	2	45	11
90	22	11	37	2	105	0	7	37	21	105	0	2	45	11
105	22	11	37	2	120	0	7	37	21	120	0	2	45	11
120	22	11	37	2	135	0	7	37	21	135	0	2	45	11
135	22	11	37	2	150	0	7	37	21	150	0	2	45	11
150	22	11	37	2	165	0	7	37	21	165	0	2	45	11
165	22	11	37	2	180	0	7	37	21	180	0	2	45	11
180	22	11	37	2	195	0	7	37	21	195	0	2	45	11
195	22	11	37	2	210	0	7	37	21	210	0	2	45	11
210	22	11	37	2	225	0	7	37	21	225	0	2	45	11
225	22	11	37	2	240	0	7	37	21	240	0	2	45	11
240	22	11	37	2	255	0	7	37	21	255	0	2	45	11
255	22	11	37	2	270	0	7	37	21	270	0	2	45	11
270	22	11	37	2	285	0	7	37	21	285	0	2	45	11
285	22	11	37	2	300	0	7	37	21	300	0	2	45	11
300	22	11	37	2	315	0	7	37	21	315	0	2	45	11
315	22	11	37	2	330	0	7	37	21	330	0	2	45	11
330	22	11	37	2	345	0	7	37	21	345	0	2	45	11
345	22	11	37	2	360	0	7	37	21	360	0	2	45	11
360	22	11	37	2	375	0	7	37	21	375	0	2	45	11
375	22	11	37	2	390	0	7	37	21	390	0	2	45	11
390	22	11	37	2	405	0	7	37	21	405	0	2	45	11
405	22	11	37	2	420	0	7	37	21	420	0	2	45	11
420	22	11	37	2	435	0	7	37	21	435	0	2	45	11
435	22	11	37	2	450	0	7	37	21	450	0	2	45	11
450	22	11	37	2	465	0	7	37	21	465	0	2	45	11
465	22	11	37	2	480	0	7	37	21	480	0	2	45	11
480	22	11	37	2	495	0	7	37	21	495	0	2	45	11
495	22	11	37	2	510	0	7	37	21	510	0	2	45	11
510	22	11	37	2	525	0	7	37	21	525	0	2	45	11
525	22	11	37	2	540	0	7	37	21	540	0	2	45	11
540	22	11	37	2	555	0	7	37	21	555	0	2	45	11
555	22	11	37	2	570	0	7	37	21	570	0	2	45	11
570	22	11	37	2	585	0	7	37	21	585	0	2	45	11
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930	22	11	37	2	945	0	7	37	21	945	0	2	45	11
945	22	11	37	2	960	0	7	37	21	960	0	2	45	11
960	22	11	37	2	975	0	7	37	21	975	0	2	45	11
975	22	11	37	2	990	0	7	37	21	990	0	2	45	11
990	22	11	37	2	1005	0	7	37	21	1005	0	2	45	11
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1035	22	11	37	2	1050	0	7	37	21	1050	0	2	45	11
1050	22	11	37	2	1065	0	7	37	21	1065	0	2	45	11
1065	22	11	37	2	1080	0	7	37	21	1080	0	2	45	11
1080	22	11	37	2	1095	0	7	37	21	1095	0	2	45	11
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1155	22	11	37	2	1170	0	7	37	21	1170	0	2	45	11
1170	22	11	37	2	1185	0	7	37	21	1185	0	2	45	11
1185	22	11	37	2	1200	0	7	37	21	1200	0	2	45	11
1200	22	11	37	2	1215	0	7	37	21	1215	0	2	45	11
1215	22	11	37	2	1230	0	7	37	21	1230	0	2	45	11
1230	22	11	37	2	1245	0	7	37	21	1245	0	2	45	11
1245	22	11	37	2	1260	0	7	37	21	1260	0	2	45	11
1260	22	11	37	2	1275	0	7	37	21	1275	0	2	45	11
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1290	22	11	37	2	1305	0	7	37	21	1305	0	2	45	11
1305	22	11	37	2	1320	0	7	37	21	1320	0	2	45	11
1320	22	11	37	2	1335	0	7	37	21	1335	0	2	45	11
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1425	22	11	37	2	1440	0	7	37	21	1440	0	2	45	11
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1455	22	11	37	2	1470	0	7	37	21	1470	0	2	45	11
1470	22	11	37	2	1485	0	7	37	21	1485	0	2	45	11
1485	22	11	37	2	1500	0	7	37	21	1500	0	2	45	11
1500	22	11	37	2	1515	0	7	37	21	1515	0	2	45	11
1515	22	11	37	2	1530	0	7	37	21	1530	0	2	45	11
1530	22	11	37	2	1545	0	7	37	21	1545	0	2	45	11
1545	22	11	37	2	1560	0	7	37	21	1560	0	2	45	11
1560	22	11	37	2	1575	0	7	37	21	1575	0	2	45	11
1575	22	11	37	2	1590	0	7	37	21	1590	0	2	45	11
1590	22	11	37	2	1605	0	7	37	21	1605	0	2	45	11
1605	22	11	37	2	1620	0	7	37	21	1620	0	2	45	11

Historic District Compatibility Analysis



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Figure 7.2 Location of the Northern Avenue Bridge

Figure 7.3 Historic Buildings Along High Street

7. Historic District Compatibility Analysis

7.1 Description of Resources

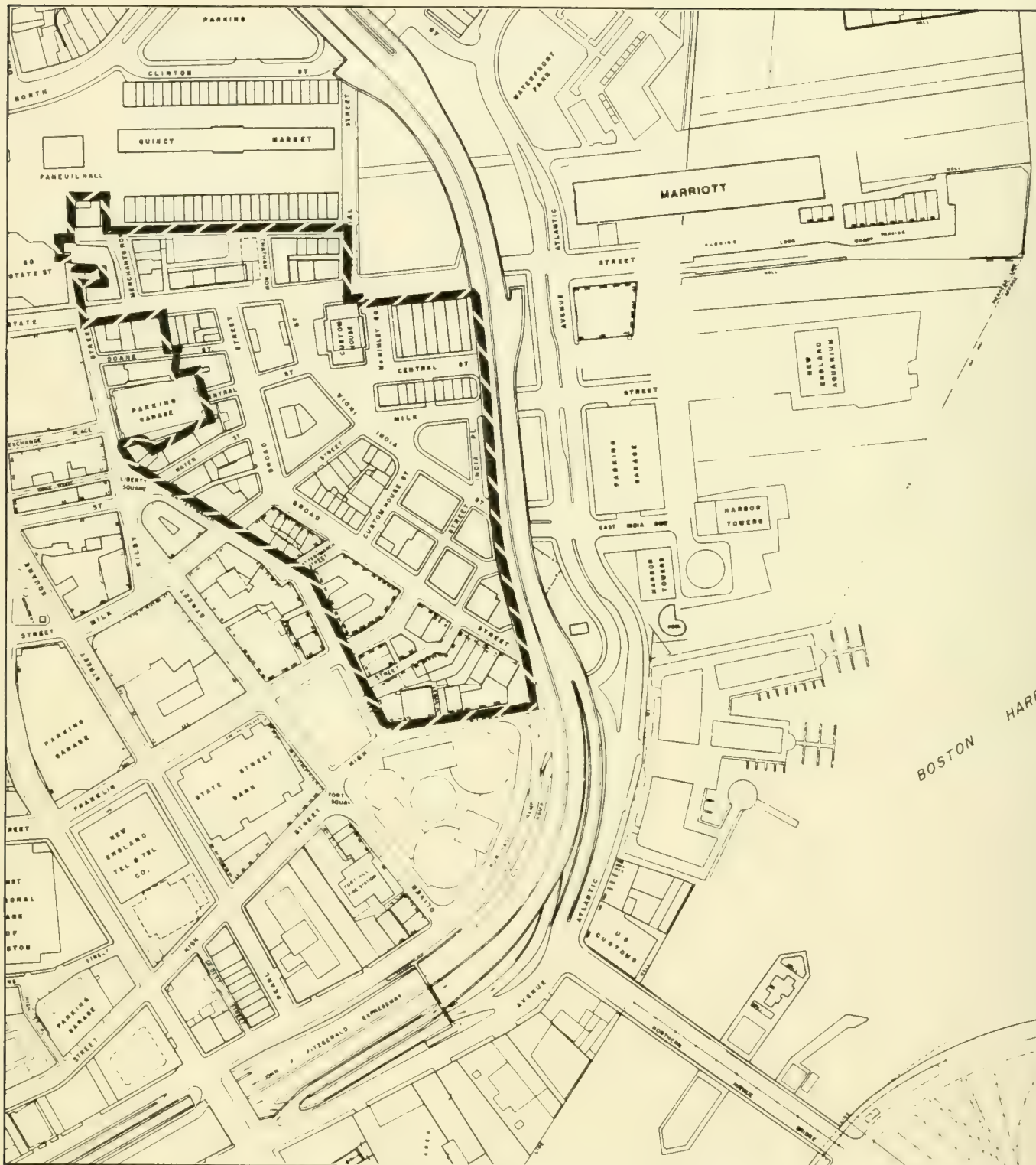
Boston is a city rich with history. It is home to both specific historic structures and "historic districts" which are areas known for activities that flourished in earlier eras. Figure 7.1 shows the historic resources in the immediate vicinity of International Place. These resources are identified on the National Register of Historic Places, or by the Boston Landmarks Commission. The nationally registered Custom House District, roughly bounded by Chatham Street, the Central Artery, Batterymarch, Banks Alley, State Street, Faneuil Hall Square and High Street, abuts the Fort Hill Square site to the north. Within this district, also known as the Broad Street District, are nine buildings individually designated as historic structures listed in the National Register. These include the buildings at 5-7, 7-9, 50-52, 64, 66, 68, 72 and 102 Broad Street, and 25-27 India Street.

There are no other nationally registered historic sites or buildings in the immediate vicinity, although the Northern Avenue Bridge (see Figure 7.2), to the east of the site on the other side of the Central Artery, is eligible for nomination to the National Register. Shadow and Wind Analyses (Sections 3. and 6.) in this report indicate no adverse impacts from the development.

7.1.1 Custom House District

"The Custom House district is an architectural environment of great heterogeneity in form, scale, materials, and styles. Constructed

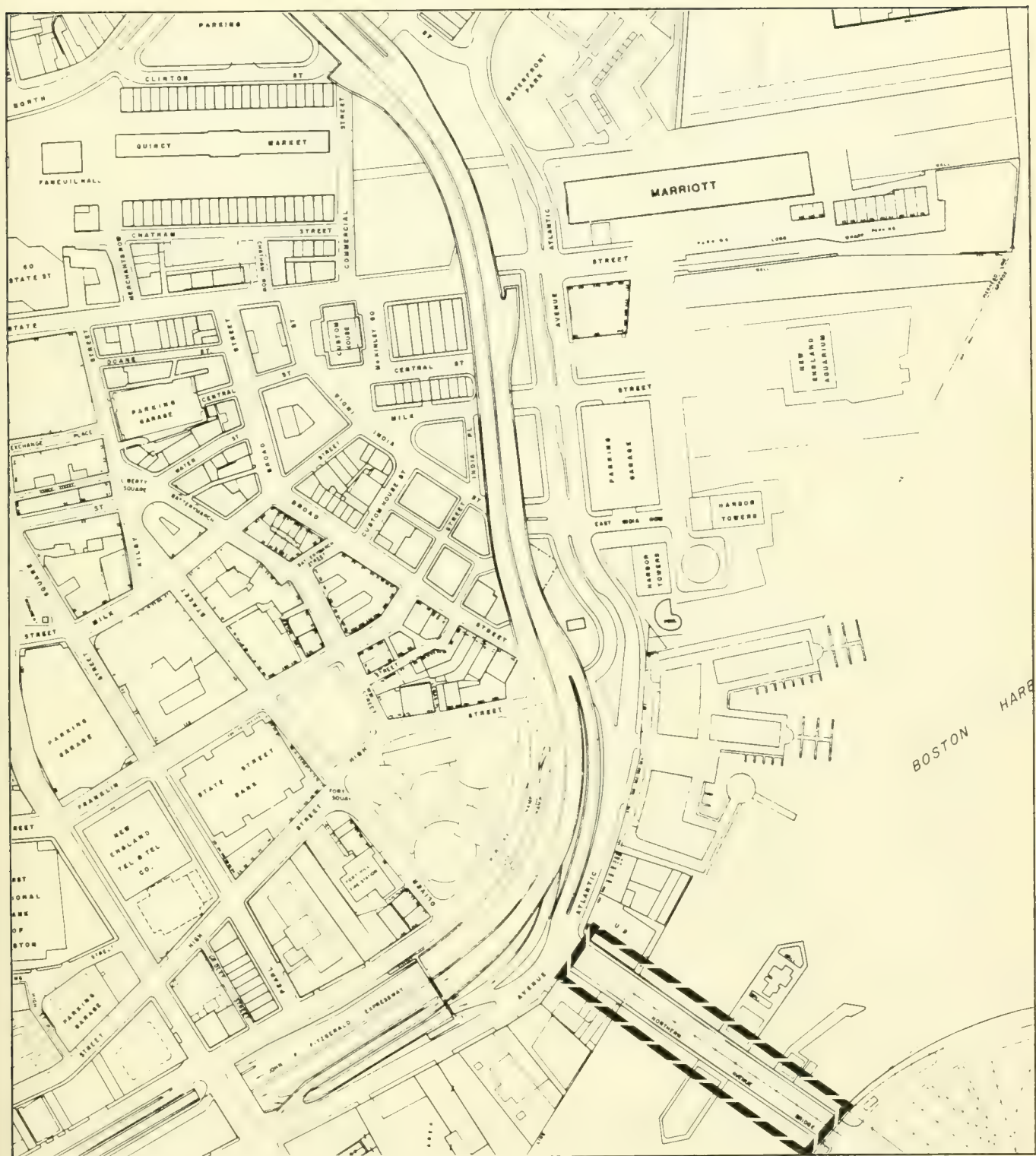
Figure 7.1 Location of Custom House District



International
Place
at Fort Hill

HMM Associates
Concord, MA

Figure 7.2 Location of the Northern Ave. Bridge



International
Place
at Fort Hill

HMM Associates
Concord, MA

through a century, the changing techniques and attitudes of development are reflected in the variety of plot sizes and building scales. Yet, the transitions between the juxtaposed forms are successful. The broad base and height of the twentieth century Batterymarch Building does not disturb the solidity of the granite warehouses. The fanciful treatment of the many Italianate structures balances the reserve of the small Federal style brick buildings. A combination of textures and colors can be found in a single building such as those facing Water Street at Liberty Square, or in a complete street scape such as Merchants Row. This variety when set upon an irregular street pattern creates many strong spaces of surprising contrast and a system of well defined vistas. The district of commercial architecture, which honors mercantile Boston, is a delicately balanced yet successful mixture.*

The streets in the Custom House District were laid out beginning with Merchant's Row in 1708 and State Street in 1710 and, and continuing throughout the Eighteenth Century. Chatham Street was laid in 1825 as part of the Quincy Market. Construction of buildings continued throughout the Nineteenth Century.

The oldest buildings in the district date from 1810. These are located along Broad Street (Numbers 5, 7, 63-73, 64-70, 72 and 102). The Custom House was built, slightly later, by Ammi B. Young between 1834 and 1847. It was originally sited at the water's edge. As a Federally-owned building, it was not bound by the City's 125 foot height restriction and thus, when the tower was added between 1913 and 1915 it became Boston's first skyscraper.* The National Register Inventory-Nomination Form for the Custom House District is included in Appendix A.

* National Register of Historic Places Inventory-Nomination Form, Custom House District

High Street Buildings

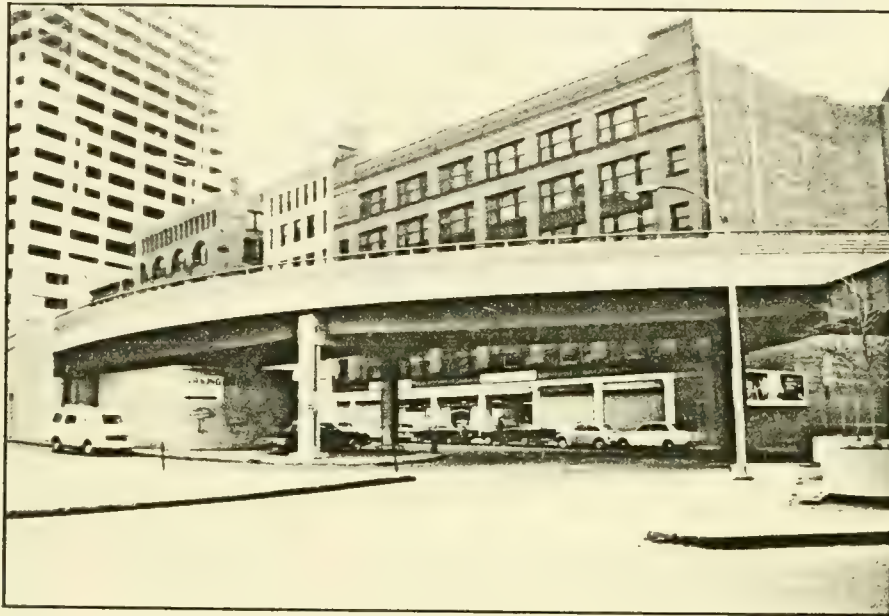
Figure 7.3 shows the four buildings along High Street that are within the Custom House District. These include the Chadwick Lead Works building at 176-184 High Street. This building was built in 1887 and was listed in the Boston Landmark Commission's 1972 Survey. It is considered an important example of commercial architecture in Boston in the period following the Great Fire of 1872. This distinctive building, boasting brownstone with terra-cotta ornamentation and archways over windows on the 5th floor, has been recently renovated to house office space and a restaurant. The adjacent building, at the corner of High Street and Batterymarch, has been renovated in conjunction with Chadwick Lead Works. The other pair of buildings, while less distinctive in appearance, have also been recently renovated for office and retail uses.

As can be seen on Figure 7.3A, the High Street Ramp from the Central Artery has a detrimental effect on the row of High Street buildings. The roadway structure spirals down to street level immediately in front of them. This degrades the pedestrian environment of the area with visual and audible disruptions associated with both the structure and the traffic it carries. In addition, the existing Fort Hill Square garage, which can be seen on Figure 7.3B, is incompatible with the row of historic structures. This twelve-story structure is composed of an unattractive yellow brick masonry with limited detailing. The garage presents a large uninterrupted facade to the Custom House District.

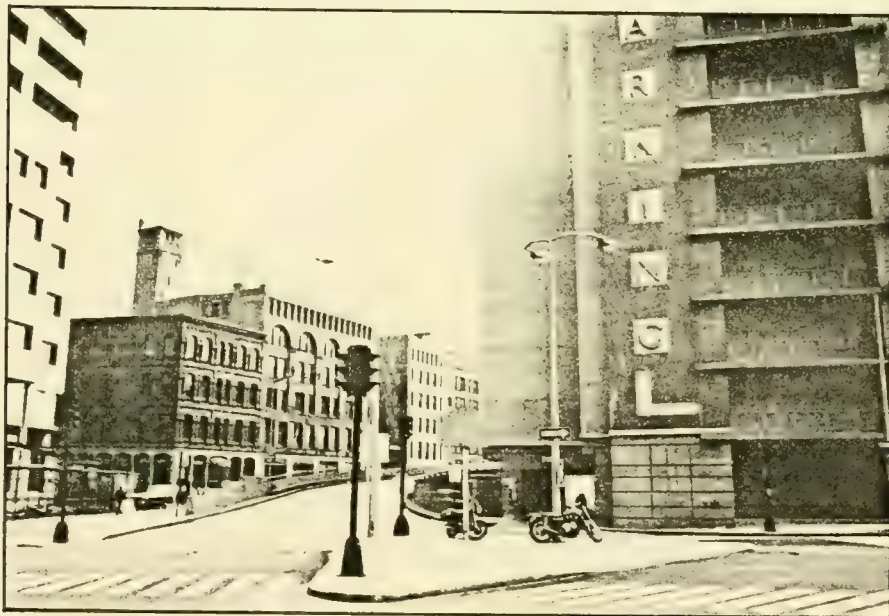
7.2 Potential Impacts to Historic Properties

The development of International Place will have positive impacts on nearby historic properties. The project will bring new activity to the site. The pedestrian environment

Figure 7.3 - Custom House District



A



B

International
Place
at Fort Hill

HMM Associates
Concord, MA

will be enhanced by retail shopping arcades facing High Street and Oliver Street. People will also be drawn to the restaurants, cafes, and to the major public amenity, a 25,000 square foot courtyard. The development will be significant in helping to revitalize the neglected southern part of the Custom House District.

High Street, as it exists today in the project vicinity, between Oliver Street and the Surface Artery, is a one-sided street with few public assets. Pedestrians use only the north side because of the artery ramp across the street. With the government-proposed relocation of this noisy, unattractive roadway element, International Place will create a vibrant, pedestrian-oriented street that will be an attractive boundary for the historic district as well as a major pedestrian route between the central shopping district and the waterfront. In addition, the development will reduce audible and visual awareness of the Central Artery, further improving the street ambience.

Throughout the course of building design and the design review process, special attention has been paid to the relationship of the development to the Custom House District. The Shadow Analysis (Section 3.) indicates few net new shadows will fall on the already heavily-shaded streets of the district and, in fact, documents a reduction in height of one tower element to benefit areas around the Flour and Grain Exchange building. Wind Analysis (Section 6.) indicates minor wind increases along High Street well under the city acceptance standard. However, in general, wind speeds along Batterymarch and Broad Street will decrease due to the wind blocking effect of the project. It is also pointed out that the project's

presence will have beneficial impacts on air pollution dispersal through vigorous vertical mixing in the atmospheric boundary layer creating a more pleasant pedestrian environment.

A low-rise project element of eleven stories, the same height as the existing garage, has been located along High Street across from the Chadwick Lead Works. (See Figures 1.10 High Street Perspective Study and 1.13 High Street Pedestrian Level in the Project Introduction of this report). Architecturally, the design recognizes the historic district scale by placing the lowest elements adjacent and stepping away to the higher elements. The building facade across from the historic district includes Palladian fenestration, columns, lintels and archways relating in architectural detail to the older buildings. The exterior granite will be flamed, rather than polished, for a flat appearance similar to the masonry, terra cotta, and granite facades of the buildings across High Street. Major entrances to International Place have been aligned to encourage pedestrian flow between the district and the project's amenities. Parking and truck access has been moved onto Purchase Street and underground to reduce traffic impacts and to prevent queuing along High Street.

In summary, the development will be beneficial to the southern end of the Custom House District by enhancing High Street, by bringing activity to the area, by eliminating a decaying city block, and by architectural sensitivity to the character of the district.

APPENDIX A

NATIONAL REGISTER INVENTORY - NOMINATION FORM

FOR THE CUSTOM HOUSE DISTRICT

NATIONAL REGISTER OF HISTORIC PLACES
INVENTORY - NOMINATION FORM

(Type all entries - complete applicable sections)

STATE: Massachusetts	
COUNTY: Suffolk	
FOR NPS USE ONLY	
ENTRY NUMBER	DATE

1. NAME	
COMMON: Custom House District	
AND/OR HISTORIC:	

2. LOCATION 9th Congressional District			
STREET AND NUMBER:			
CITY OR TOWN: Boston			
STATE Massachusetts	CODE 025	COUNTY: Suffolk	CODE 025

3. CLASSIFICATION			
CATEGORY (Check One)	OWNERSHIP	STATUS	ACCESSIBLE TO THE PUBLIC
<input checked="" type="checkbox"/> District <input type="checkbox"/> Building <input type="checkbox"/> Site <input type="checkbox"/> Structure <input type="checkbox"/> Object	<input type="checkbox"/> Public <input type="checkbox"/> Private <input checked="" type="checkbox"/> Both	Public Acquisition: <input type="checkbox"/> In Process <input type="checkbox"/> Being Considered	<input checked="" type="checkbox"/> Occupied <input checked="" type="checkbox"/> Unoccupied <input checked="" type="checkbox"/> Preservation work in progress
PRESENT USE (Check One or More as Appropriate)			
<input type="checkbox"/> Agricultural <input checked="" type="checkbox"/> Commercial <input type="checkbox"/> Educational <input checked="" type="checkbox"/> Entertainment	<input checked="" type="checkbox"/> Government <input type="checkbox"/> Industrial <input type="checkbox"/> Military <input type="checkbox"/> Museum	<input type="checkbox"/> Park <input checked="" type="checkbox"/> Private Residence <input type="checkbox"/> Religious <input type="checkbox"/> Scientific	<input type="checkbox"/> Transportation <input type="checkbox"/> Other (Specify) _____ _____ _____
Comments _____ _____			

4. OWNER OF PROPERTY			
OWNER'S NAME: public and private			
STREET AND NUMBER:			
CITY OR TOWN: Boston	STATE: Massachusetts	CODE 025	

5. LOCATION OF LEGAL DESCRIPTION			
COURTHOUSE, REGISTRY OF DEEDS, ETC: Registry of Deeds			
STREET AND NUMBER: Suffolk County Courthouse			
CITY OR TOWN: Boston	STATE: Massachusetts	CODE 025	

6. REPRESENTATION IN EXISTING SURVEYS			
TITLE OF SURVEY: Historic American Building Survey Mass. -125, -789			
DATE OF SURVEY: 1935 <input checked="" type="checkbox"/> Federal <input type="checkbox"/> State <input type="checkbox"/> County <input type="checkbox"/> Local			
DEPOSITORY FOR SURVEY RECORDS: Library of Congress			
STREET AND NUMBER:			
CITY OR TOWN: Washington	STATE: D.C.	CODE	

SEE INSTRUCTIONS

STATE: Massachusetts	COUNTY: Suffolk	ENTRY NUMBER	DATE
-------------------------	--------------------	--------------	------

FOR NPS USE ONLY

7. DESCRIPTION

CONDITION	(Check One)					
	<input checked="" type="checkbox"/> Excellent	<input checked="" type="checkbox"/> Good	<input checked="" type="checkbox"/> Fair	<input checked="" type="checkbox"/> Deteriorated	<input type="checkbox"/> Ruins	<input type="checkbox"/> Unexposed
	(Check One)			(Check One)		
	<input checked="" type="checkbox"/> Altered	<input checked="" type="checkbox"/> Unaltered		<input type="checkbox"/> Moved	<input checked="" type="checkbox"/> Original Site	

DESCRIBE THE PRESENT AND ORIGINAL (if known) PHYSICAL APPEARANCE

The Custom House District of 15.9 acres includes the property within a line beginning at #1 Faneuil Hall Square turning south on Merchants Row for one block, turning east on Chatham Street, turning south on Commercial Street, turning east on State Street, turning south at the central artery of the John F. Fitzgerald Expressway continuing along the artery to High Street, continuing west on High Street to northwest on Batterymarch, turning east on Kilby Place, turning north at the back lot line of #30 Kilby Street, turning west on Bangs Alley, turning north at the back lot line of #15 Broad Street, and west of #99 State Street, turning west on State Street and north to the side lot line of #74 State Street, including the back lot line of #10 Merchants Row and #1 Faneuil Hall Square.

The Custom House District is an exhibit of mixed commercial architecture reflecting Boston's development as a major mercantile city. Originally, State and its extension, Long Wharf, plus Kilby and Batterymarch St. were the streets which converged with the early wharves and their scattering of small buildings. State Street, existing since Boston's founding, was extended to Long Wharf in 1710. This street and active pier formed the main link from the waterfront to Washington Street, the central axis to the neck. Chatham Street was laid in 1825 as part of the Quincy Market development to improve market facilities at Faneuil Hall. The resulting six new streets lined with stores and warehouses held the over flow of goods from Merchant's Row (laid in 1708).

In 1805 the Broad Street Association led by Uriah Cotting, with Charles Bulfinch as planner, began a development which altered the colonial waterfront both north and south of Long Wharf. By a land fill operation south of Long Wharf, they organized a street pattern dominated by two wide streets, Broad and India, which generally followed the contours of the harbor and were crossed by smaller access streets. Combined with the contiguous areas of the Markets and Faneuil Hall and the financial center on State Street, this expanded district became the center of Boston's merchant energies through the early years of the 19th century.

MAJOR STRUCTURES

The oldest buildings (c. 1810) in this district are #5, 7, 63-73, 64-70, 72, 102 Broad Street and #175 Milk Street(1). These Federal style buildings are the remnants of those erected from the design of Bulfinch for the Broad Street Association. Each building is of brick and was originally 4 stories in height with flared lintels, the 4th story windows being characteristically smaller and square. The cornice was a simple brick imitation of dentils and a string course of stone separated the stories. Originally the street level consisted of a central doorway flanked by two windows. Hipped roofs topped the edifices. Although significant alterations to window openings, ground floors, and roof lines have occurred, the Federal style and scale is still clearly preserved.

Central Wharf(2) at 146-176 Milk Street (1819) consisted of a row of 54 brick stores down the center of a wharf and formed the continuation of Milk Street. Surviving today are only eight of the original fifty-four units. Like the other Federal-style buildings in this district, each unit consisted of 4 stories, three bays with two six over six pane sashes flanking a central doorway at street level and capped by a hipped roof.

SEE INSTRUCTIONS

3. SIGNIFICANCE

PERIOD (Check One or More as Appropriate)

- | | | | |
|--|---------------------------------------|--|---------------------------------------|
| <input type="checkbox"/> Pre-Columbian | <input type="checkbox"/> 16th Century | <input checked="" type="checkbox"/> 18th Century | <input type="checkbox"/> 20th Century |
| <input type="checkbox"/> 15th Century | <input type="checkbox"/> 17th Century | <input checked="" type="checkbox"/> 19th Century | |

SPECIFIC DATE(S) (If Applicable and Known)

AREAS OF SIGNIFICANCE (Check One or More as Appropriate)

- | | | | |
|--|---------------------------------------|---|--|
| <input type="checkbox"/> Aboriginal | <input type="checkbox"/> Education | <input type="checkbox"/> Political | <input checked="" type="checkbox"/> Urban Planning |
| <input type="checkbox"/> Prehistoric | <input type="checkbox"/> Engineering | <input type="checkbox"/> Religion/Phi- | <input type="checkbox"/> Other (Specify) |
| <input type="checkbox"/> Historic | <input type="checkbox"/> Industry | <input type="checkbox"/> Josophy | |
| <input type="checkbox"/> Agriculture | <input type="checkbox"/> Invention | <input type="checkbox"/> Science | |
| <input checked="" type="checkbox"/> Architecture | <input type="checkbox"/> Landscape | <input type="checkbox"/> Sculpture | |
| <input type="checkbox"/> Art | <input type="checkbox"/> Architecture | <input type="checkbox"/> Social/Human- | |
| <input checked="" type="checkbox"/> Commerce | <input type="checkbox"/> Literature | <input type="checkbox"/> itarian | |
| <input type="checkbox"/> Communications | <input type="checkbox"/> Military | <input type="checkbox"/> Theater | |
| <input type="checkbox"/> Conservation | <input type="checkbox"/> Music | <input type="checkbox"/> Transportation | |

STATEMENT OF SIGNIFICANCE

The Custom House district is significant as an example of foresighted urban planning, by the Broad Street Associates, which allowed for the evolution of a district of commercial architecture reflective of a continually growing and prosperous mercantile Boston.

The Federal style buildings on Broad and Milk Streets are the sole surviving examples of the planned effort by Charles Bulfinch to create order for waterfront commerce. Building requirements were specified and adhered to for the sake of unity and the cohesive pattern of this development can still be observed. The small scale, mass, and fenestration of the Federal style is particularly noteworthy in this district where later more monumental styles are interwoven.

Central Wharf built by 1819 is the only remaining brick structure that exemplifies the architecture of Boston's early eighteenth century wharves. Similar to Bulfinch's India Wharf (demolished by 1968) and the other Federal-style buildings in this district, Central Wharf is easily distinguished in McKinley Square - beside the monumental granite edifices in view.

Built by Ammi B. Young between 1834-47 the Custom House on the corner of India and State Streets was originally at the water's edge, an ideal location for its use. With inspiration from classical Greece, the revival style was found to be an appropriate architectural form to express the confidence and dignity of an emerging Boston. As a Federally-owned building, it was not bound by the city's 125' height restriction, and, thus, when the tower was added, between 1913 and 1915, it became the first skyscraper in Boston.

The Grain and Flour Exchange, designed by Shepley, Rutan and Coolidge in 1890-92, commands the area of McKinley Square. Its rounded massing provides a striking contrast in scale, form and character to the other brick and granite buildings. This structure is one of the fine examples of Romanesque Revival architecture in the city of Boston.

Granite structures were the pride of mid-nineteenth century Boston. The new technology for transporting large blocks of granite catalyzed the change in scale of commercial buildings. Small brick warehouses and wharf buildings gave way to monumental blocks of granite. Economy of detail in these buildings places greater emphasis on the massive form. Granite warehouses were built in great numbers from the 1820's to 1860's, but only a few survive to reflect the power and prosperity of this mercantile port.

SEE INSTRUCTIONS

NATIONAL REGISTER OF HISTORIC PLACES
INVENTORY - NOMINATION FORM

(Continuation Sheet)

STATE Massachusetts	
COUNTY Suffolk	
FOR NPS USE ONLY	
ENTRY NUMBER	DATE

(Number all entries)

6. Boston Landmarks Commission Survey
1972 Local
Boston Redevelopment Authority
City Hall
Boston, Massachusetts 025

7. Continued

Presently, ground floor alterations and additional floors on several units exist, yet the original window pattern, brick, and general scale are still retained.

The Custom House(3) at McKinley Square is a prime example of the Greek Revival style. Basically a version of a Doric temple, the longitudinal axis is crossed by a truncated axis with the crossing originally covered by a saucer dome. A giant Doric colonnade surrounds the two story granite structure which is set on a high basement. Under the pedimented gable ends, entrance is reached by a flight of steps. The reposed templar design was altered earlier in this century when its dome was removed, and a 16 story office tower was constructed.

Opposite the Custom House is the Flour and Grain Exchange(4), 177 Milk Street, illustrating the medievalizing trend in later Victorian architecture. Its blunt rounded granite facade and steep conical roof give the structure a picturesque silhouette as well as indicating its massive volume. The fenestration is arranged under connecting three story arches to emphasize the trading floor. String courses at each floor level provide a horizontal emphasis contrasting the vertical thrust of the windows which is continued in the peaked dormer windows, which creates a coronet around the roof cone.

The State Street Block(5), 177-199 State Street, designed by Gridley J. F. Bryant (1858) is a massive structure of dark rough-hewn granite. Granite ornamentation is severe and limited to the keystones of the segmental-arched windows, plain string courses, and the heavy bracketed cornice. On the McKinley Square facade, the cornice breaks into an arched pediment under which a decorative globe of the world is mounted. Although the Block was truncated by demolition of the majority of its bays and some roof and ground floor alterations have occurred, the monumental character of the building is preserved.

The mixed commercial fabric of this district is further enhanced by several structures illustrating later Victorian architectural style.

Two rough-hewn granite-faced buildings remain at #50 (c. 1860) and 109 Broad Street (1870)(6). Both display mansard roofs and string courses between stories. #50 Broad Street has a more consciously decorative use of granite in the corbelled cornice, bracketed lintels, and on the ground floor, arched keystone window frames. #109 Broad Street has segmental arched windows still intact on the upper floors, but ground floor alterations obscure the original openings.

#99 Broad Street (1854) and the Pond Building (1854)(7) at #1 Faneuil Hall Square are noteworthy examples of slab-granite construction. The huge flat surfaced blocks are interrupted only by the trabeated window and door openings.

NATIONAL REGISTER OF HISTORIC PLACES
INVENTORY - NOMINATION FORM

(Continuation Sheet)

STATE Massachusetts	
COUNTY Suffolk	
FOR NPS USE ONLY	
ENTRY NUMBER	DATE

(Number all entries)

7. Continued

The Chadwick Lead Works 176-184 High Street(8). Designed by William G. Preston in 1887 with a functional lead drop tower, it is a leading example of commercial architecture in Boston after the fire of 1872. It is a brick structure with brownstone and terra cotta ornamentation, and large round headed arches containing pairs of windows.

The Harvard Club, 22 Batterymarch(9). This handsome French Renaissance Revival edifice was designed by Ball and Dabney in 1893. It is a brick building with a stone ground floor decorated with keyed voussoir arches and paired windows above outlined by a narrow stone molding.

114 State Street(10). This cast-iron commercial building, circa 1860, with arcaded fenestration is the only one of its kind in the district. The ground floor has been altered radically.

8. Continued

The Custom House district is an architectural environment of great heterogeneity in form, scale, materials, and styles. Constructed through a century, the changing techniques and attitudes of development are reflected in the variety of plot sizes and building scales. Yet, the transitions between the juxtaposed forms are successful. The broad base and height of the twentieth century Batterymarch Building does not disturb the solidity of the granite warehouses. The fanciful treatment of the many Italianate structures balances the reserve of the small Federal style brick buildings. A combination of textures and colors can be found in a single building such as those facing Water Street at Liberty Square, or in a complete street scape such as Merchants Row. This variety when set upon an irregular street pattern creates many strong spaces of surprising contrast and a system of well defined vistas. This district of commercial architecture, which honors mercantile Boston, a delicately balanced yet successful mixture.

9. Continued

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9. MAJOR BIBLIOGRAPHICAL REFERENCES

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Herndon, Richard. Boston of To-Day. Boston, 1892.

Shurtleff, Nathaniel Bradstreet. A Topographical and Historical Description of Boston. Boston, 1870.

10. GEOGRAPHICAL DATA

LATITUDE AND LONGITUDE COORDINATES DEFINING A RECTANGLE LOCATING THE PROPERTY			OR	LATITUDE AND LONGITUDE COORDINATES DEFINING THE CENTER POINT OF A PROPERTY OF LESS THAN TEN ACRES		
CORNER	LATITUDE	LONGITUDE		LATITUDE	LONGITUDE	
	Degrees Minutes Seconds	Degrees Minutes Seconds		Degrees Minutes Seconds	Degrees Minutes Seconds	
NW	42° 21.34.79	71° 03 23.93		° . .	° . .	
NE	42° 21.34.79	71° 03 07.87				
SE	42° 21.23.07	71° 03 07.87				
SW	42° 21.23.07	71° 03 23.93				

APPROXIMATE ACREAGE OF NOMINATED PROPERTY: 15.9

LIST ALL STATES AND COUNTIES FOR PROPERTIES OVERLAPPING STATE OR COUNTY BOUNDARIES

STATE:	CODE	COUNTY:	CODE
STATE:	CODE	COUNTY:	CODE
STATE:	CODE	COUNTY:	CODE
STATE:	CODE	COUNTY:	CODE

11. FORM PREPARED BY

NAME AND TITLE: Carol Todreas, Deborah Gott-lin		
ORGANIZATION Boston Landmarks Commission	DATE February 1973	
STREET AND NUMBER: City Hall		
CITY OR TOWN: Boston	STATE Massachusetts	CODE 025

12. STATE LIAISON OFFICER CERTIFICATION

NATIONAL REGISTER VERIFICATION

As the designated State Liaison Officer for the National Historic Preservation Act of 1966 (Public Law 89-665), I hereby nominate this property for inclusion in the National Register and certify that it has been evaluated according to the criteria and procedures set forth by the National Park Service. The recommended level of significance of this nomination is:

National ☐ State ☐ Local ☐

Name _____

Title _____

Date _____

I hereby certify that this property is included in the National Register.

Chief, Office of Archeology and Historic Preservation

Date _____

ATTEST:

Keeper of The National Register

Date _____

SEE INSTRUCTIONS

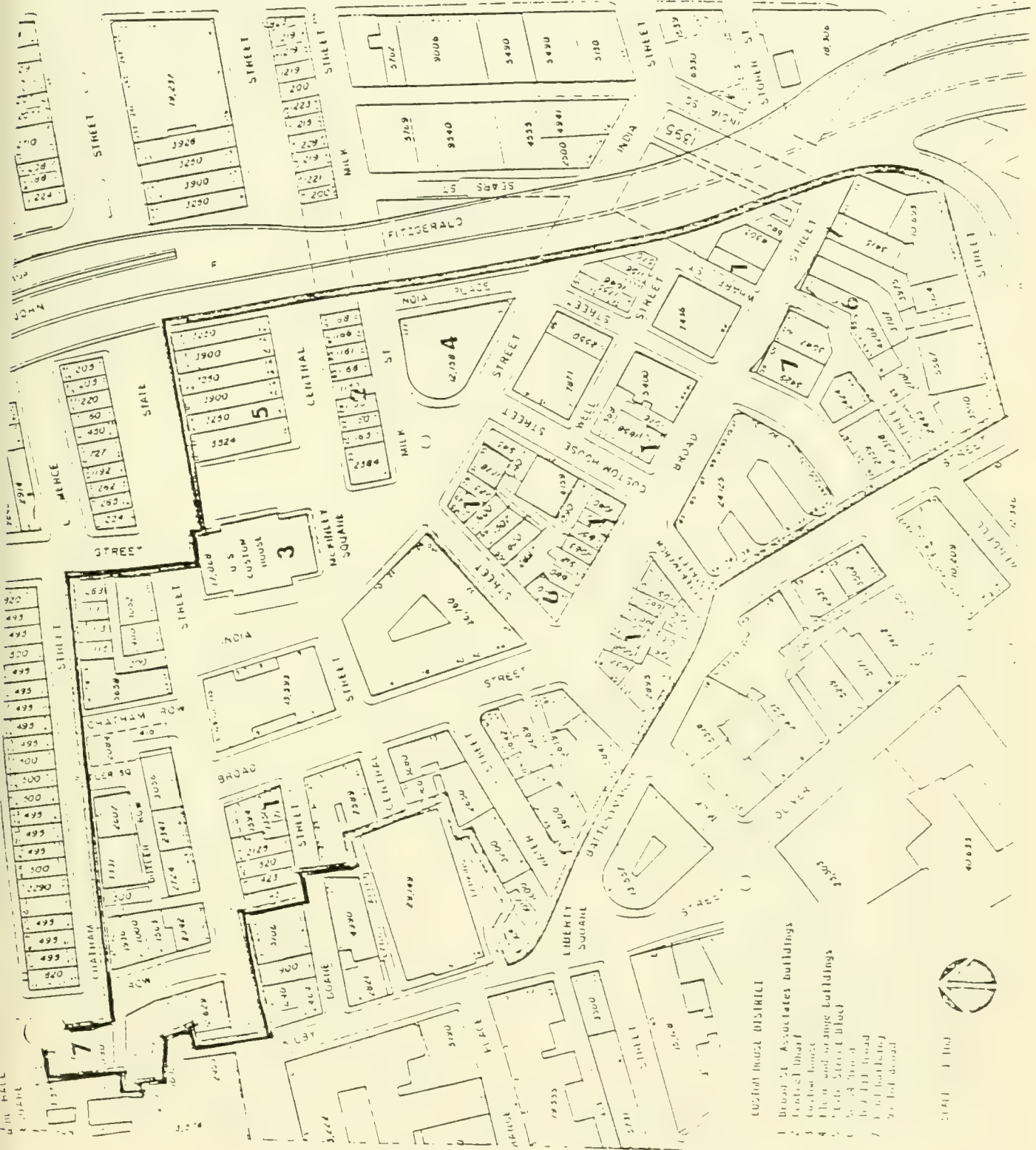
NATIONAL REGISTER OF HISTORIC PLACES
PROPERTY MAP FORM

(Type all entries - attach to or enclose with map)

STATE Massachusetts	
COUNTY Suffolk	
FOR NPS USE ONLY	
ENTRY NUMBER	DATE

SEE INSTRUCTIONS

1. NAME			
COMMON: Custom House District			
AND/OR HISTORIC:			
2. LOCATION			
STREET AND NUMBER:			
CITY OR TOWN: Boston			
STATE: Massachusetts	CODE 025	COUNTY: Suffolk	CODE 025
3. MAP REFERENCE			
SOURCE: Topographic & Planimetric Survey of the City of Boston			
SCALE: 1:100			
DATE: 1967			
4. REQUIREMENTS			
TO BE INCLUDED ON ALL MAPS			
1. Property boundaries where required.			
2. North arrow.			
3. Latitude and longitude reference.			



171M1510 750.44 440.4267

- 1 Broad St. Associates buildings
- 2 Federal Bank
- 3 Federal Trust
- 4 Flat and Orange buildings
- 5 City State Bldg
- 6 1000
- 7 1111 Broad
- 8 1111 Broad
- 9 1111 Broad
- 10 1111 Broad



— 111 —

NATIONAL REGISTER OF HISTORIC PLACES

PROPERTY MAP FORM

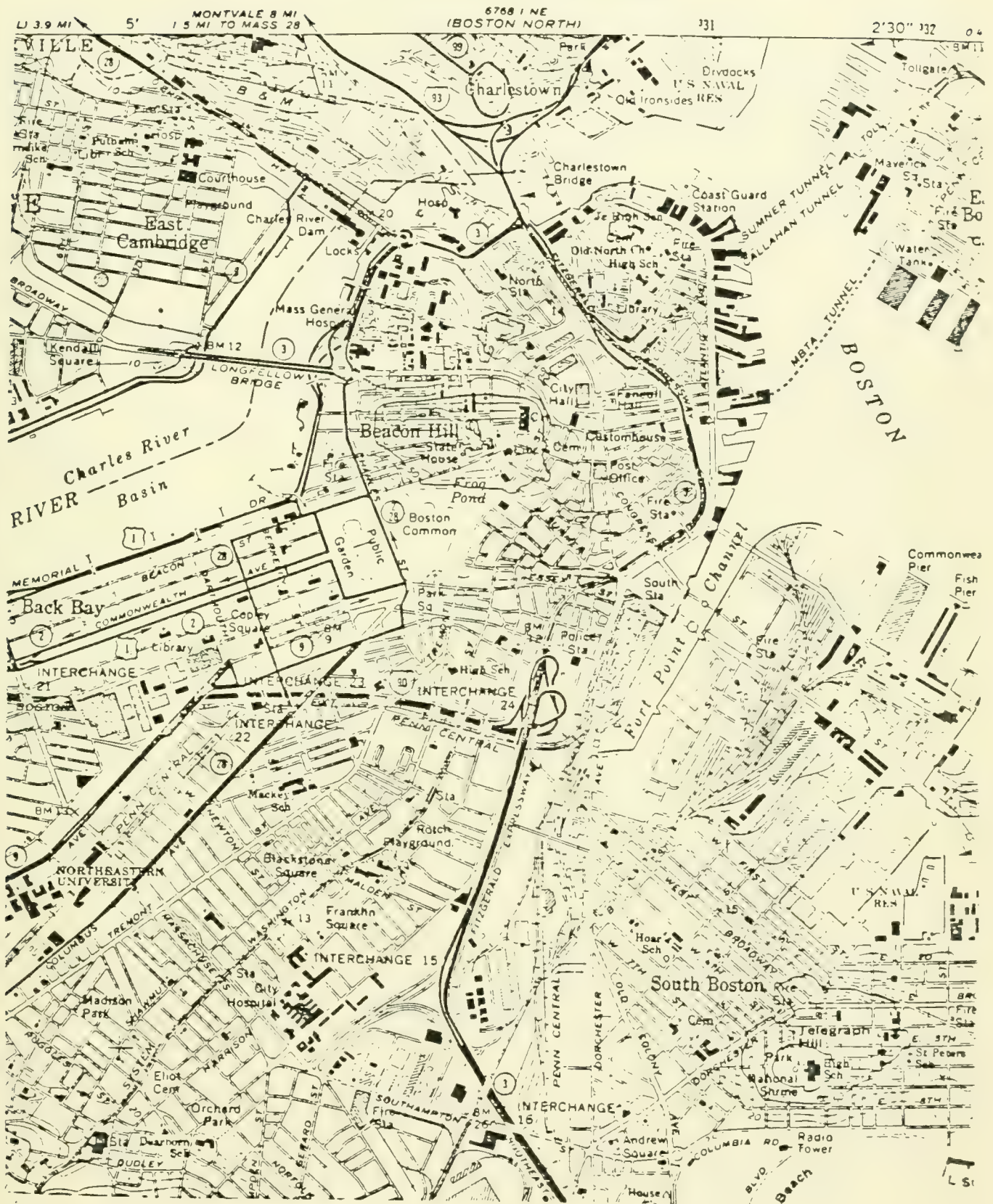
(Type all entries - attach to or enclose with map)

STATE Massachusetts	
COUNTY Suffolk	
FOR NPS USE ONLY	
ENTRY NUMBER	DATE

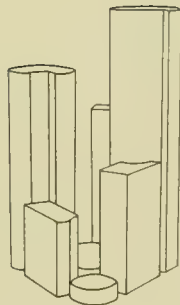
SEE INSTRUCTIONS

1. NAME			
COMMON: Custom House District		AND/OR HISTORIC	
2. LOCATION			
STREET AND NUMBER.			
CITY OR TOWN: Boston			
STATE: Massachusetts	CODE 025	COUNTY: Suffolk	CODE 025
3. MAP REFERENCE			
SOURCE: USGS 7.5' Series Boston South Quadrangle			
SCALE: 1:24,000			
DATE: 1956			
4. REQUIREMENTS			
TO BE INCLUDED ON ALL MAPS			
1. Property boundaries where required.			
2. North arrow.			
3. Latitude and longitude reference.			

COMMONWEALTH OF MASSACHUSETTS
DEPARTMENT OF PUBLIC WORKS



Utility Systems (Sewer)



III. Sewer Systems Analysis of International Place, Boston

for

The Chiofaro Company
One Post Office Square
Suite 3100
Boston, Massachusetts 02109

by

HMM Associates
336 Baker Avenue
Concord, Massachusetts 01742

The following Utility Systems (Sewer) report supplants the initial analysis submitted to the Boston Redevelopment Authority as part of the May, 1984 EIR. It is the same report submitted to the Massachusetts Secretary of Environmental Affairs office as the Final EIR in compliance with G.L., Chapter 30, Section 62-62H and the regulations implementing the Massachusetts Environmental Protection Agency (MEPA). As such, it incorporates the comments received from public agencies and private organizations, including those from the BRA. Further responses to BRA comments are contained in the Comments and Responses section of this Report.

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5.1 SEWER SYSTEMS*

5.1.1 Sewer System for Fort Hill Square Site

The City of Boston has a public sewer system that is operated by the Boston Water and Sewer Commission (BWSC). Throughout most of the downtown and financial districts of the city, service consists of a combined storm water surface runoff-sanitary waste sewer. Sanitary wastewater and storm water from the existing buildings and areas at the Fort Hill Square Site are collected by these combined sewers and directed to the East Side Interceptor (ESI) which passes close to the site and conveys the wastewater to the Boston Main Interceptor, and then on to the Metropolitan District Commission's (MDC) Deer Island Treatment Plant. At Deer Island the wastewater receives primary treatment and chlorination before being discharged to Boston Harbor.

The present sewer system at the site is shown on Figure 5.1.1. The system from the site to the ESI and overflow outfalls to Boston Harbor is shown on Figure 5.1.2. Each of the street sewers currently in place in the site area is discussed below.

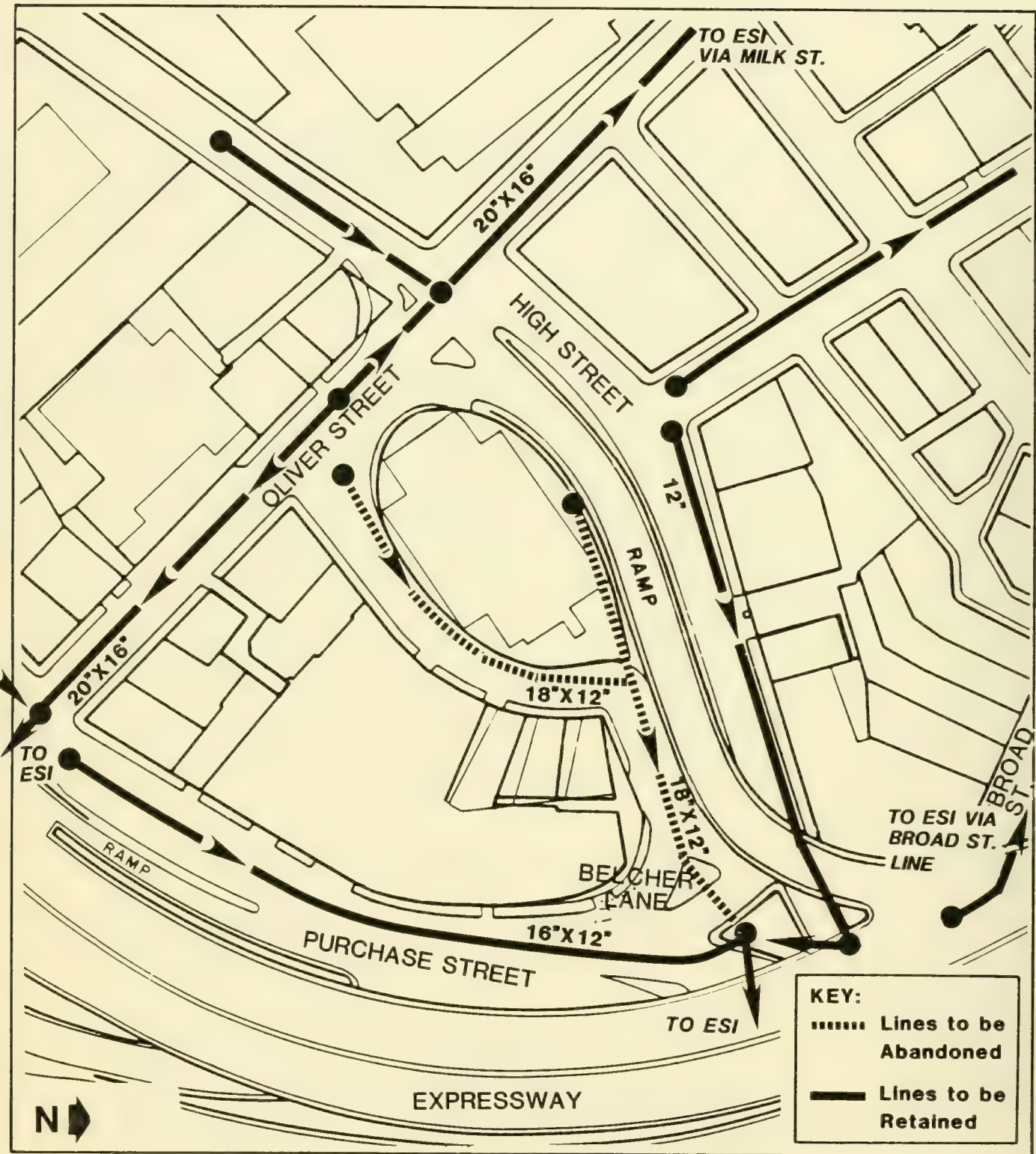
5.1.2 Sewer System - Site to East Side Interceptor

Oliver Street Sewer

The Oliver Street sewer is a 20" x 16" egg-shaped combined storm and sanitary sewer. Sewage from the southern part

* Data sources for this section include discussions with BWSC, MDC and Camp, Dresser and McKee (project designer for the new East Side Interceptor), as well as working maps from the Central Arteries Utility Inventory and the "Combined Sewer Overflow Project, Inner Harbor Area Facilities Plan," MDC, December 1982, prepared by O'Brien & Gere Engineers, Inc.

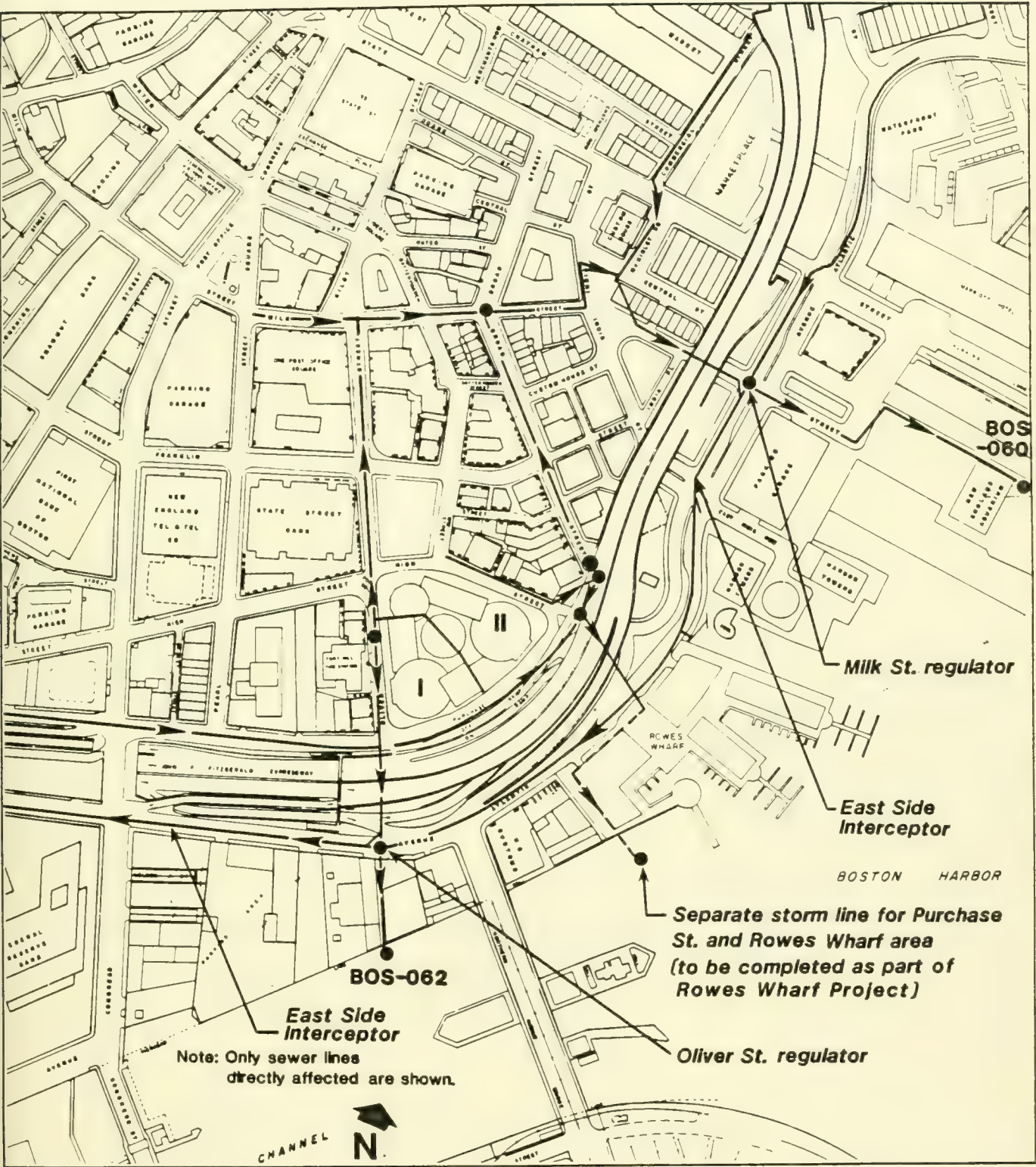
Figure 5.1.1 Sewer System at Fort Hill Square Site



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HMM Associates
Concord, MA

Figure 5.1.2 Site Vicinity Sewer Lines



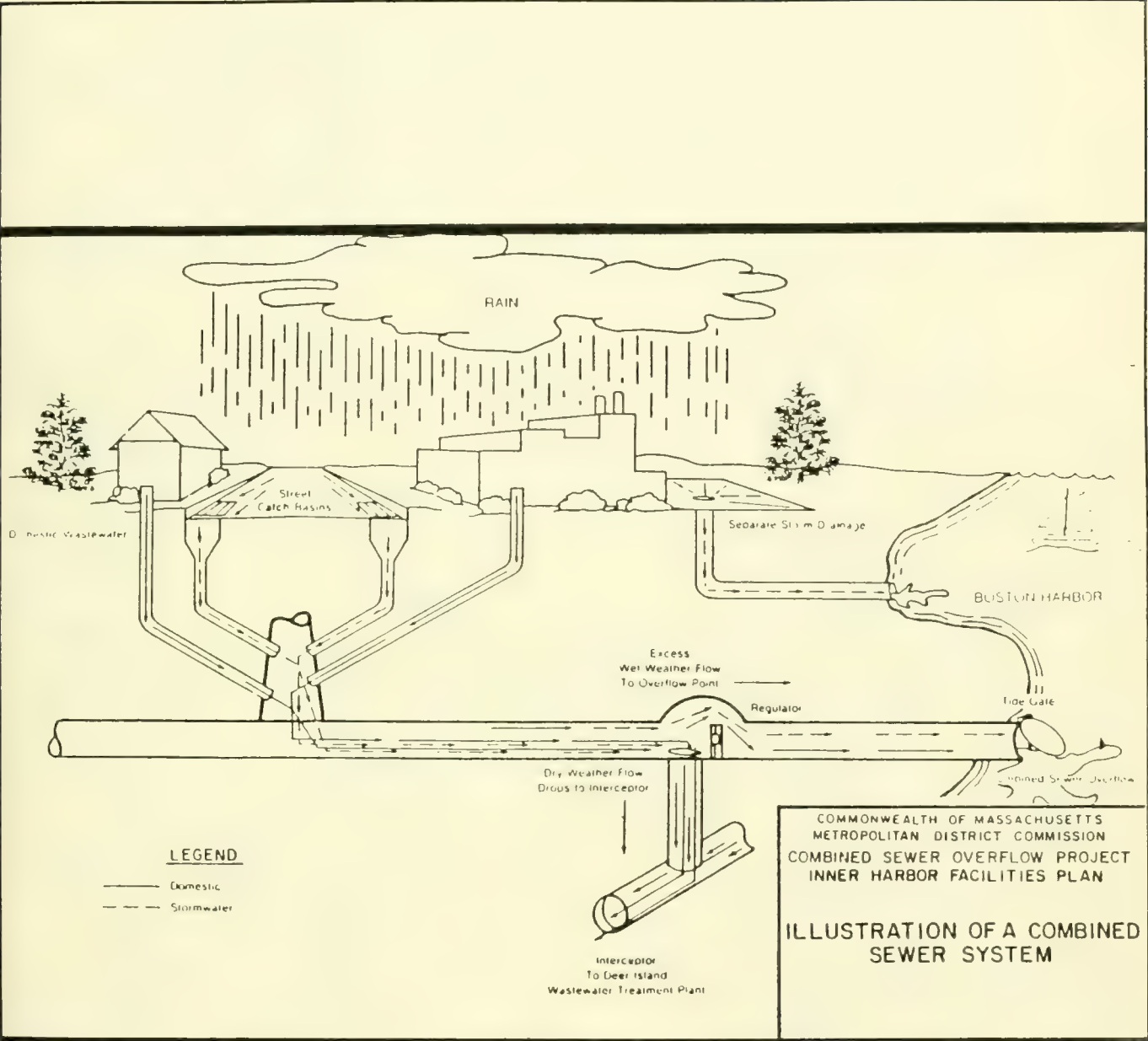
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of the site enters this sewer and flows southeast to a 72" pipe located at the Oliver Street-Purchase Street intersection. This pipe collects sewage from Oliver Street and other combined sewers serving 70 acres of Boston in the Summer Street and Essex Street areas southwest of the site and conveys it under the Central Artery and Atlantic Avenue to the ESI. A regulator in the conduit at this location diverts all dry weather flow into the ESI. Excess wet weather flow overflows the regulator, bypasses the ESI and is discharged into Fort Point Channel just south of Northern Avenue at outfall BOS-062 (see Figure 5.1.2). Figure 5.1.3 presents an illustration of the operation of a typical regulator during storm flow situations.

At the northern end of the site the sewer flow is in the other direction on Oliver Street due to an elevation change occurring about 350 feet northwest of the Oliver-Purchase Street intersection. There the flow is into a 20" x 16" egg-shaped combined sewer which runs northwest to a larger pipe at Milk Street (51" x 54" expanding to 60" x 64") which collects the sewage from Oliver Street as well as sewage from much of the financial district, including Post Office Square and the Federal-Congress Street areas. The line proceeds to an ESI regulator at Atlantic Avenue and Milk Street near Central Wharf (see Figure 5.1.2). Here dry weather flow enters the ESI while excess wet weather flow overflows the regulator, bypasses the ESI and is discharged into the Harbor via a CSO (known as BOS-060) off Central Wharf.

Figure 5.1.3 Typical Combined Sewer System



Source: "Combined Sewer Overflow Project Inner Harbor Area Facilities Plan",
MDC, December 1982, O'Brien & Gere

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Purchase Street Sewer

The Purchase Street sewer is a 16" x 12" egg-shaped combined sewer which carries sewage to a 60" x 64" conduit under the Central Artery and Atlantic Avenue to the ESI. Previously, excess wet weather flows were discharged to the Harbor via a CSO (known as BOS-061) between Rowe's Wharf and Foster's Wharf. However, this CSO has been closed off (Ref. 1).*

High Street Sewer

The High Street sewer is an 18" x 12" combined sewer which serves High Street and the High Street exit ramp from the expressway. Sewage is conveyed down High Street where it joins with the Purchase Street sewer. Sewage then proceeds, as described above, to the ESI (see Figure 5.1.2).

5.1.3 Sewer System - East Side Interceptor to Deer Island

Existing System

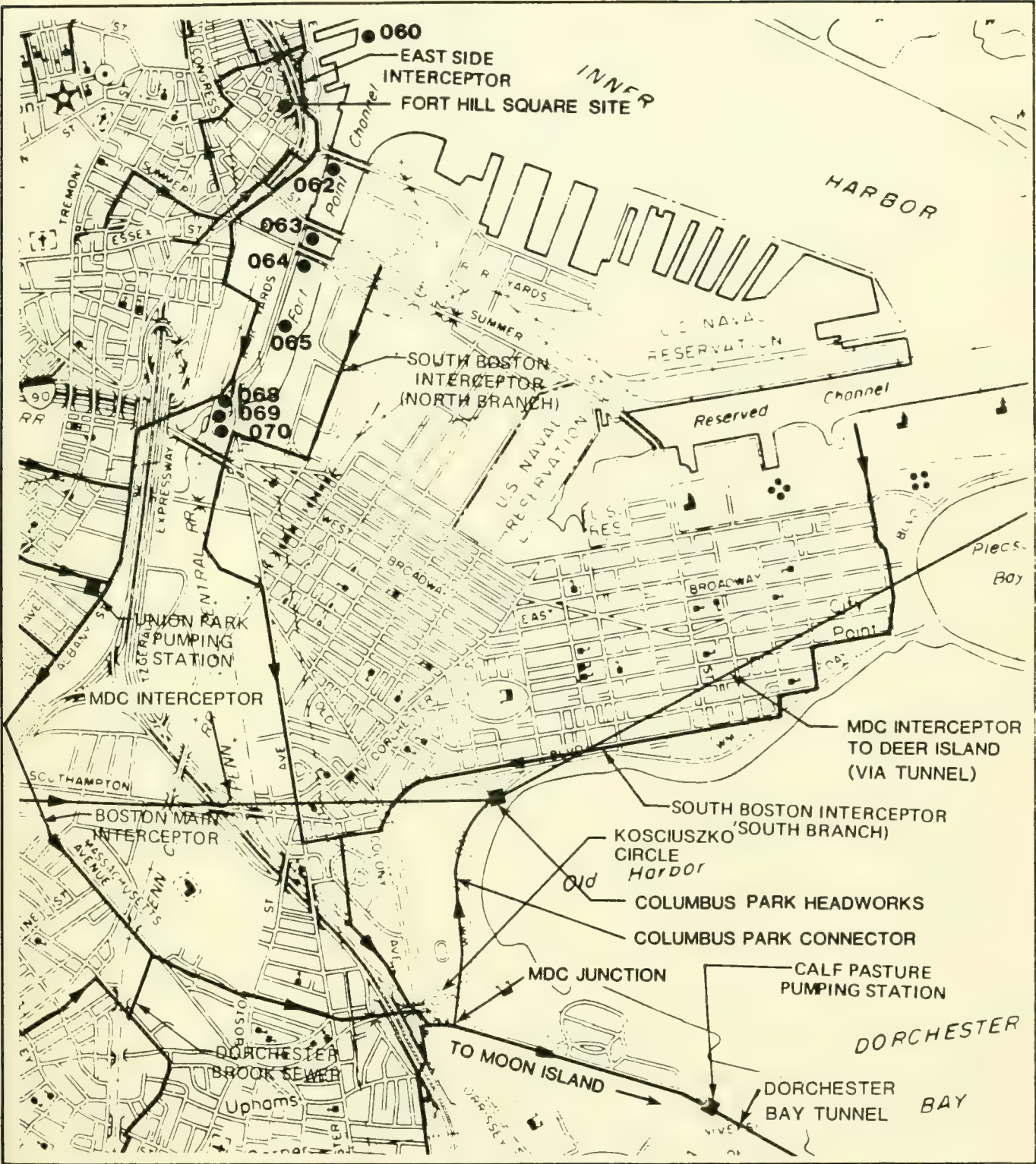
East Side Interceptor

The East Side Interceptor (ESI) conveys dry weather flows and some wet weather flows from the downtown Boston Waterfront area, North End sections of Boston and portions of the South End, to the Boston Main Interceptor at Massachusetts Avenue and Albany Street. The interceptor is served by a series of regulators (see Figure 5.1.3) which divert sewage flow from various trunk lines into the ESI. Figure 5.1.4 presents the route of the ESI to the Boston Main Interceptor.

The ESI begins at Hanover Street and continues to the south along Commercial Street and then along Atlantic

* See Reference listing at the end of this section.

Figure 5.1.4 Existing Boston Interceptor System



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Avenue south to Beach Street. It then proceeds south, under the South Station Railroad Yard, reaching Albany Street near Herald Street. It continues along Albany Street to the junction with the Boston Main Interceptor at Massachusetts Avenue.

The portion of the ESI north of the site from Eastern Street to Harbor Towers was replaced as part of the Waterfront Park Project. The Boston Water and Sewer Commission has initiated a project to replace the remainder of the ESI by the end of 1987. This is discussed in more detail later.

In the vicinity of the project site, the existing ESI is a 100 year old 32" x 59" oblong brick conduit. Full flow capacity varies between 5 and 9 million gallons per day (MGD) in the section of the ESI from Central Wharf south to Rows Wharf. It gradually increases in size until it reaches 48" x 60" at its junction with the Boston Main Interceptor. At this point, full flow capacity is approximately 36 MGD.

As described in the O'Brien and Cere report (Ref. 2), the ESI has a tributary area of 485 acres and served a daytime population of 171,500 people in 1980. Estimated average dry weather flows are about 8.1 MGD at the junction with the Boston Main Interceptor (Ref. 2). During certain storm conditions, peak flows reach the design capacity of the ESI. In the site vicinity this would be 5-9 MGD. At the junction with Boston Main Interceptor this would be 36 MGD.

In addition to the two combined sewer overflows (CSO) described previously (BOS-060 and BOS-062), there are six other CSOs between the project site and the Boston Main Interceptor. These CSOs discharge excess wet weather flow into the Fort Point Channel at various locations as shown on Figure 5.1.4 (BOS-063, 064, 065, 068, 069 and 070).

Table 5.1.1 presents additional data on each of these outfalls.

Significant problems exist in the ESI in the vicinity of the site area. These problems have included improper performance of regulators and tidegates, and sedimentation in the line. In addition, the construction of the new section of the ESI along the Waterfront Park Project area has resulted in a hydraulic constraint in the ESI that will not be eliminated until the remainder of the replacement project is completed in 1987. The new section north of Harbor Towers is a 66" line with a capacity of 36 MGD. The old section south of Harbor Towers is a 32" x 59" line with a capacity of 9 MGD. Also, at this point, the new section is approximately two feet below the old section of the ESI. This difference in elevation and capacity acts as an obstruction in the ESI which serves to back up flow in the pipe. This condition appears to have created constant surcharge conditions in the ESI and may be contributing to dry weather overflows at CSOs north of the site (BOS-057, 058 and 060) (Ref. 1).

A further problem creating periodic surcharge conditions in some portions of the combined sewers in the site area is improper operation of tidegates. Much of the system in the area is below high tide level. Tidegates are intended to close during high tide periods to prevent inflow of sea water from the Harbor. The gates can become blocked open or broken such that tidal inflow into the CSO is not prevented. This allows water from the Harbor to reach the ESI and combined sewers.

The Boston Water and Sewer Commission has initiated a number of recent actions to improve combined sewer operations. The Commission has, since 1980, been conducting an ongoing inspection and maintenance program

TABLE 5.1.1

COMBINED SEWER OVERFLOWS

<u>Designator</u>	<u>Location</u>	<u>Limiting Pipe** Capacity</u>	<u>Outfall Pipe Size</u>
*BOS-057	Sargent's Wharf (Eastern Avenue)	442.4 MGD	96"
*BOS-058	Between Long Wharf and Commercial Wharf	292.2 MGD	84"
BOS-060	Central Wharf	88.6 MGD	72"
BOS-061	Rowes Wharf	No longer in use	
BOS-062	Ft. Point Channel South of Northern Avenue Bridge	86.7 MGD	54"x72"
BOS-063	Ft. Point Channel at Congress Street	8.7 MGD	36"
BOS-064	Ft. Point Channel at Summer Street	4.3 MGD	60"
BOS-065	Ft. Point Channel at Kneeland Street	97.4 MGD	81"
BOS-068	Ft. Point Channel at Broadway Bridge	205 MGD	72"
BOS-069	Ft. Point Channel at Fourth St. Bridge	43.7 MGD	48"
BOS-070	Ft. Point Channel at Fourth St. Bridge (Roxbury Canal Conduit)	935 MGD	2 @ 240"x180"

* Not directly affected by project sewer flows

** Limiting pipe capacity depends on slope and size of pipes serving the outfall.

Note: All data are from "Combined Sewer Overflow Project, Inner Harbor Facilities Plan," MDC, December, 1982, prepared by O'Brien & Gere Engineers, Inc.

along the ESI and its associated CSO's. This program includes inspections and required maintenance of regulators and tidegates on a schedule of two times each quarter. Tidal inflow is currently a problem at BOS-060 (Central Wharf) and BOS-058 (Long Wharf) due to corrosion of the seatface of the tidegates. This corrosion has resulted in an incomplete seal which allows tidal inflow. The result is that sea water occupies capacity in the pipes that would normally be available to wastewater. This sea water also is conveyed to Deer Island Treatment Plant, thereby adding additional hydraulic loads to that facility. Additionally, the presence of sea water in the system exacerbates the problem of dry weather discharge of wastewater to the Harbor. These damaged gates are expected to be repaired in 1985 (Ref. 1).

In addition to maintenance programs and periodic inspections underway since 1980, the Boston Water and Sewer Commission requires the use of sewage retention tanks for all large developments in the area tributary to the ESI. These retention tanks are sized to collect an entire day's generation of sanitary wastewater from the building. This wastewater is then discharged during the two four-hour periods of the day when the tide is lowest. Surcharging in the sewer system often results from the tidal inflow during high tide periods. By discharging during low tide periods, the building minimizes the impact of its sewage on this tidal surcharging problem.

The most important action undertaken by the Boston Water and Sewer Commission has been the initiation of design of the replacement for the ESI from the new waterfront section all the way to the Boston Main Interceptor. This new ESI is expected to eliminate surcharging, thus eliminating dry weather overflows and

reducing the amount of wet weather overflow in the waterfront area at BOS-057, 058 and 060. This replacement program is discussed in more detail later.

Boston Main Interceptor

In the Boston Main Interceptor (BMI) sewage generally flows from west to east through the southern part of Boston. The BMI serves to convey flows from the other Boston interceptors (including the East Side Interceptor) to the junction with the MDC system in the Columbia Point area. Interceptors discharging into the BMI include the Roxbury Canal Sewer, the Dorchester Brook Sewer, the Dorchester Interceptor, and the north branch of the South Boston Interceptor, as well as the East Side Interceptor. The BMI's route is shown on Figure 5.1.4. It runs easterly along Camden Street to Washington Street, and on to Massachusetts Avenue where it continues east to a junction chamber near Kosciuszko Circle. Along this route, the BMI collects flow from the East Side Interceptor near the intersection of Albany Street and Washington Street. At that point, the BMI is a 90' x 92" conduit with a peak flow capacity of 123 MGD. Average dry weather flows in the BMI are estimated to be about 44 MGD (Ref. 2).

The BMI conveys flows from Boston's various interceptors to a junction chamber located near Kosciuszko Circle (see Figure 5.1.4). At this chamber, flow is directed north along the MDC Columbus Park Connector (116" x 87" pipeline) to the MDC Columbus Park Headworks and MDC Tunnel and on to the Deer Island Treatment Plant. Average flow in the connector is approximately 64 MGD (Ref. 1).

Beyond the Headworks, the BMI on Mt. Vernon Street at Columbia Point serves primarily as a storm drain (Ref. 1).

MDC Tunnel to Deer Island

Wastewater collected in the Boston Water and Sewer Commission's system enters the MDC system at the Columbus Park Headworks which has a capacity of 180 MGD (Ref. 2). Average dry weather flow to the headworks is approximately 64 MGD (Ref. 1). The MDC Tunnel which conveys sewage from the Columbus Park Headworks to the Deer Island Treatment Plant has a peak capacity of 440 MGD (Ref. 2).

In 1983 the Deer Island Treatment Plant had a maximum hourly design treatment rate of 925 MGD. The design pumping capacities of the headworks serving Deer Island totaled 888 MGD in 1983. Actual average flow through the plant in 1983 was 290 MGD compared to the average daily design flow of 343 MGD. The treatment plant provides primary treatment and chlorination prior to discharging the wastewater (Ref. 12).

Calf Pasture Pumping Station to Moon Island

When flows exceed available capacity in the Columbus Park Headworks, wastewater continues along the Boston Main Interceptor on Mt. Vernon Street to the Calf Pasture Pumping Station and then on to Moon Island via the Dorchester Bay Tunnel. The Moon Island outlet facility serves as a wet weather and partial dry weather bypass for the MDC's Deer Island Treatment Plant. Currently, overflows at Moon Island occur at a rate of 40 to 60 days per year. In 1981 and 1982 when pumping problems existed at Deer Island, there were 227 discharges from Moon Island. When upgrading of the MDC's Deer Island Treatment Plant is completed in 1987, it is expected that there will be about 12 discharges per year at Moon Island. Historically, these discharges have been on the order of 5 to 16 million gallons each occurrence. After 1987, discharges are expected to be less than 12 million gallons each occurrence (Ref. 3).

Water Quality Implications

Previous sections have described the current sewer system and the problems with its operations. The O'Brien and Gere report (Ref. 2) estimates that storm-related combined sewer overflows to Boston Harbor occur on the order of 50-100 times a year dependent upon storm conditions. These overflows vary in length from several minutes to several hours. Although no data are available on specific overflows, O'Brien & Gere estimated that the 108 combined sewer overflows which discharge to Boston Harbor and its tributary rivers from Boston, Cambridge, Somerville, Chelsea and Brookline (see Figure 5.1.5) resulted in approximately 11 billion gallons of combined sewer overflow in 1979. Sixty-four of these CSOs are in Boston, with eleven associated with the ESI (see Table 5.1.1). More recent MDC estimates indicate that recent improvements have decreased the combined total of these CSO discharges from Boston, Cambridge, Somerville, Chelsea and Brookline to about 5.7 billion gallons a year (Ref. 5, Ref. 13). Table 5.1.2 presents data characterizing the water quality of these overflows.

These overflows have resulted in a number of water quality problems in the Harbor. Massachusetts Water Quality Standards dictate the pollutant levels that must be met for various uses of water. In Boston Harbor water uses are often jeopardized by CSO discharges. The major pollutants of concern are pathogenic microorganisms (indicated by total and fecal coliform), suspended solids, biochemical oxygen demand (BOD), floating materials and oil and grease. Table 5.1.3 presents a summary of water quality in Boston Inner Harbor. Table 5.1.4 presents a summary of Massachusetts water quality standards applicable to Boston Harbor.

Figure 5.1.5 Existing Combined Sewer Overflow Outlets



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TABLE 5.1.2
OVERFLOW WATER QUALITY

	Dry Weather	Combined Sewer Wet Weather
Total Coliform (colonies/100 ml)	7.1x10 ⁸	3.7x10 ⁷
Fecal Coliform (colonies/100 ml)	3.6x10 ⁷	2.7x10 ⁶
BOD	129.4	68.7
TSS	132.5	109.9
Hg	.5	1.5
Pb	.05	.06
Cu	.09	.09
Zn	.13	.13
Cl	.01	.04
Cr	.05	.05
TOC	103.2	41.8
COD	454.8	121.0

Reference: Combined Sewer Overflow Project Inner Harbor
Area Facilities Plan," MDC, December, 1982,
O'Brien and Gere Engineers, Inc.

TABLE 5.1.3
WATER QUALITY SUMMARY BOSTON INNER HARBOR
(mg/l)

<u>Parameter</u>	<u>Maximum</u>	<u>Minimum</u>	<u>Average</u>
pH ¹	8.0	7.6	7.8
Suspended Solids ¹	35.0	16.0	22.0
Oil and Grease ¹	2.6	0.0	1.3
Total Kjeldahl Nitrogen ¹	2.4	0.64	1.23
Ammonia Nitrogen ¹	0.19	0.01	0.07
Sulfate ¹	3,325	1,950	2,488
Total Phosphorus ¹	0.10	0.02	0.05
Conductivity ¹ (umhos/cm)	40,000	34,000	38,800
Total Coliform ¹ (# organisms/100 ml)	2,400	230	711 ³
Fecal Coliform ¹ (# organisms/100 ml)	380	20	105 ³
Chloride ¹	14,000	11,000	13,300
Arsenic ²	0.001	--	0.001
Cadmium ²	0.014	0.0005	0.009
Chromium ²	0.004	--	0.004
Copper ²	0.01	0.0014	0.006
Lead ²	0.017	0.002	0.012
Mercury (ug/l) ²	0.05	0.005	0.035
Nickel ²	0.02	0.004	0.016
Silver ²	0.08	--	0.08
Vanadium ²	0.04	--	0.04
Zinc ²	0.145	0.002	0.05
Dissolved Oxygen ¹			
Surface	8.5	5.2	7.2
Middle (13'-18')	6.8	5.4	5.9
Bottom (26'-40')	6.8	3.4	5.5

Sources:

- 1 Massachusetts Department of Environmental Quality Engineering from sampling locations BH03 (Boston Inner Harbor north of mouth of Charles River near U.S. Naval Reserve), BH0-4 (tidal portion of Charles River downstream of Charlestown Bridge) and BH05 (Main Chamel of Boston Inner Harbor near mouth of Fort Point Channel) surveyed July 14-15, 1983. Personal communication.
- 2 U.S. Army Corps of Engineers, 1981 and Massport Seaport Development, 1980.
- 3 Geometric mean of DWPC Data.

Reference: "DEIS Third Harbor Tunnel Project, Interstate 80, Appendix 7," U.S. DOT, MDPW, December 1982.

TABLE 5.1.4
WATER QUALITY STANDARDS

<u>Parameter</u>	<u>Criteria</u>
<u>For All Waters</u>	
1. Aesthetics	All waters shall be free from pollutants in concentrations or combinations that: (a) Settle to form objectionable deposits; (b) Float as debris, scum or other matter to form nuisances; (c) Produce objectionable odor, color, taste or turbidity; or (d) Result in the dominance of nuisance species.
2. Radioactive Substances	Shall not exceed the recommended limits of the United States Environmental Protection Agency's National Drinking Water Regulations.
3. Tainting Substances	Shall not be in concentrations or combinations that produce undesirable flavors in the edible portions of aquatic organisms.
4. Color, Turbidity, Total Suspended Solids	Shall not be in concentrations or combinations that would exceed the recommended limits on the most sensitive receiving water use.
5. Oil and Grease	The water surface shall be free from floating oils, grease and petrochemicals and any concentrations or combinations in the water column or sediments that are aesthetically objectionable or deleterious to the biota are prohibited. For oil and grease of petroleum origin the maximum allowable discharge concentration is 15 mg/l.
6. Nutrients	Shall not exceed the site-specific limits necessary to control accelerated or cultural eutrophication.

TABLE 5.1.4 (Cont'd)
WATER QUALITY STANDARDS

<u>Parameter</u>	<u>Criteria</u>
<u>For All Waters (Cont'd)</u>	
7. Other Constituents	<p>Waters shall be free from pollutants in concentrations or combinations that:</p> <ul style="list-style-type: none"> (a) Exceed the recommended limits on the most sensitive receiving water use; (b) Injure, are toxic to, or produce adverse physiological or behavioral responses in humans or aquatic life; or (c) Exceed site-specific safe exposure levels determined by bioassay using sensitive resident species.
<u>For Class SC Waters</u>	
1. Dissolved Oxygen	Shall be a minimum of 85 percent of saturation at water temperature above 77°F(25°C) and shall be a minimum of 6.0 mg/l at water temperature of 77°F(25°C) and below.
2. Temperature	None except where the increase will not exceed the recommended limits on the most sensitive water use.
3. pH	Shall be in the range of 6.5-8.5 standard units and not more than 0.2 units outside the naturally occurring range.
4. Fecal Coliform Bacteria	Shall not exceed a log mean for a set of samples of 1000 MPN per 100 ml, nor shall more than 10% of the total samples exceed 2500 MPN per 100 ml during any monthly sampling period, except as provided in 310 CMR 4.02(1).

Within the Harbor violations of Water Quality Standards are as follows (Ref. 2):

- o Coliform bacteria standards are intermittently or continually violated in all areas.
- o Dissolved oxygen standards are frequently violated in the Inner Harbor as well as other locations.
- o Floating materials and oil and grease violate the standards in all areas.

It is clear that insufficient capacity and hydraulic constraints in the East Side Interceptor cause dry weather overflow and increased wet weather overflow in the site vicinity. The Boston Water and Sewer Commission reports that dry weather overflow appears to be more or less continuous during periods of low tide at BOS-057 off Sargent's Wharf and BOS-060 off Central Wharf (Ref. 1). This is likely caused by the hydraulic constraint in the ESI where the new waterfront section meets the old section near Harbor Towers. The O'Brien and Gere report (Ref. 2) states that in 1979 dry weather overflows at BOS-060 appeared to average 1.54 MGD. The Boston Water and Sewer Commission also reports that some smaller dry weather overflows occur occasionally at BOS-062 and other outfalls along Fort Point Channel (FOS-063, 064, 065, 068, 069, 070), although these tend to be much less frequent and are attributed to surcharging in the ESI (Ref. 1). At BOS-062, the BWSC reports that the outfall is visited approximately 8 times each year and overflows are observed 2-3 times each year. No specific records on these overflow volumes have been compiled. The BWSC expects to issue a contract by the end of 1984 which will include

metering outfalls in this area. Detailed information on the frequency and quantity of overflows at BOS-060 and 062 should be available in 1985 (Ref. 1).

It is likely that all of the CSO's show overflow during any appreciable storm event. While no specific data are currently available on volume or frequency, O'Brien and Gere (Ref. 2) has estimated that nearly 40% of the pollutant loading caused by CSO's comes from BOS-070, the Roxbury Canal Conduit at the southern end of Fort Point Channel.

Plans for System Improvements - East Side and Boston Main Interceptor Replacement

O'Brien and Gere (Ref. 2) has concluded that most water quality problems in the Inner Harbor can be significantly reduced if dry weather overflows are eliminated and if wet weather combined sewer overflows are properly controlled. Currently, the Metropolitan District Commission and the Boston Water and Sewer Commission are working on elements of a Recommended Plan for CSO control (Ref. 5). The plan is intended to eliminate dry weather overflow by in-system modifications to tidegates and regulators, by improvements in collection capacity (e.g., new East Side Interceptor) and by continuing inspection and maintenance programs. The plan also calls for reductions of up to 75% in the frequency and volume of CSO. The goal is to provide treatment for all storms with a probability of occurring less than once per year with a six hour duration.

In conjunction with this plan, the Boston Water and Sewer Commission has initiated a \$60 million design and construction program to replace major sewer interceptor pipes. The program is designed to eliminate dry weather overflows caused by insufficient capacity in the existing systems and to provide replacements where the system has

deteriorated. Funding for the project is provided by the federal government (75 percent), the state (15 percent) and the BWSC (10 percent) (Ref. 7). Design of the improvements began in January of 1980. Construction began in 1982 and is anticipated to run through 1989 for all system improvements (Ref. 1, Ref. 7).

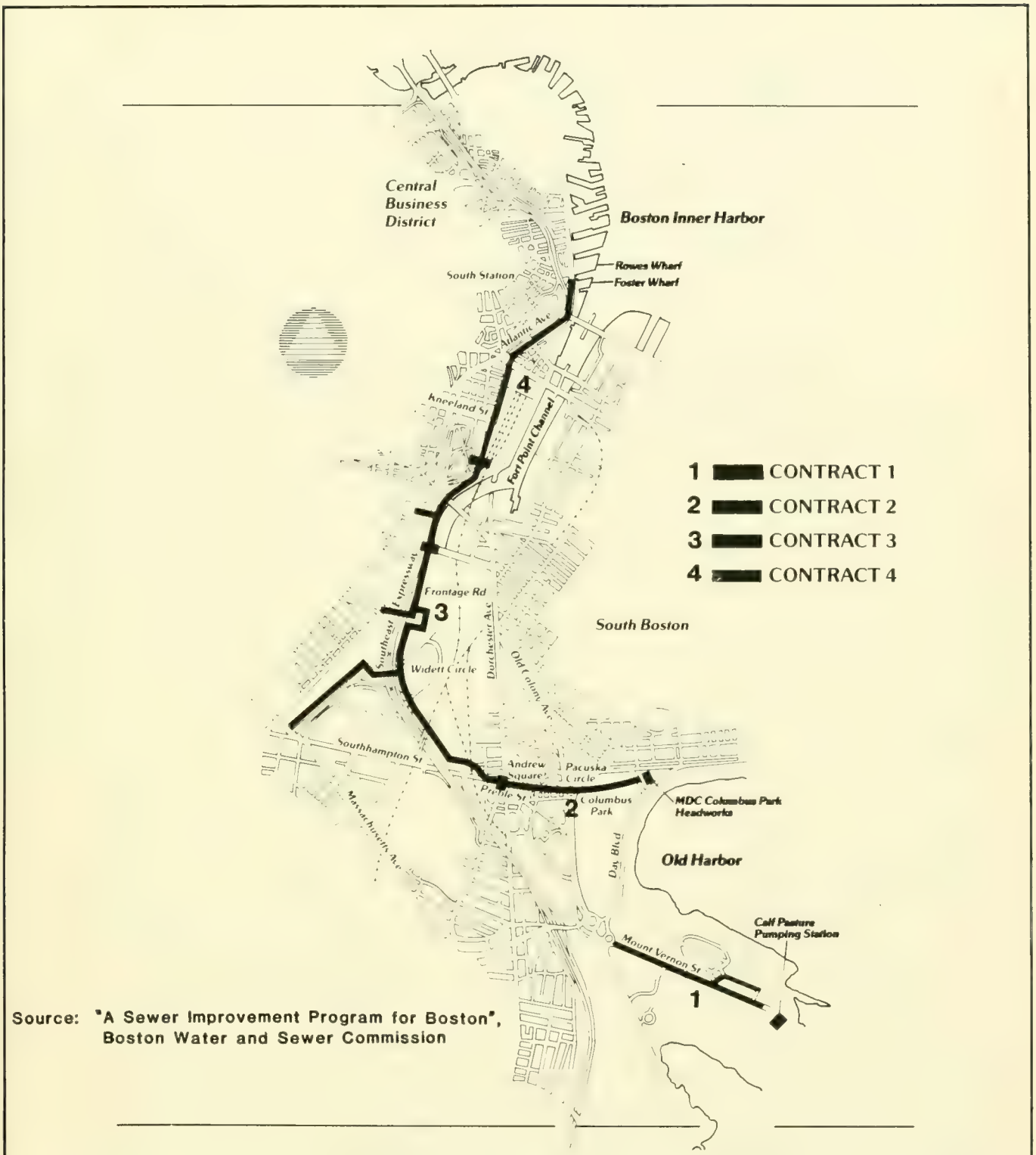
The new interceptors will extend from the MDC's Columbus Park Headworks, in South Boston, to Atlantic Avenue near Rows Wharf. Construction of the interceptors is divided into four major segments as shown on Figure 5.1.6. The new East Side Interceptor will receive wastewater from the downtown area. The New Boston Main Interceptor will carry this flow as well as wastewater received from portions of Roxbury and Dorchester, South Boston and the South End.

The first segment, which was completed in 1983, is the Mount Vernon Street Sewer (see Figure 5.1.6). This segment provides a separate sanitary sewer to serve Columbia Point.

The second segment, which was completed early in 1984, is the portion of the New Boston Main Interceptor which runs from Andrew Square to the MDC Columbus Park Headworks. This 102" pipeline is 2650 feet long and has a capacity of 166 MGD. The existing BMI's equivalent capacity is 123 MGD (Ref. 8). This pipeline receives flow from the south branch of the South Boston Interceptor.

The third segment will replace the portion of the old East Side Interceptor and old Boston Main Interceptor that runs from the South Station Railroad Yard down to Andrew Square. This will be 9000 feet of 84" and 102" pipeline with capacities ranging from 136 to 166 MGD (compared to the current 36 MGD) (Ref. 8). This segment also includes an extension of the East Side Interceptor from Widett Circle to Massachusetts Avenue to serve the South End and

Figure 5.1.6 New Interceptor Lines



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parts of Roxbury. This line is 3000 feet of 60" pipe. The third segment was started in 1984 and will be completed in 1986.

The fourth segment will replace the old East Side Interceptor from Harbor Towers, where the new ESI completed with the Waterfront Project ends, to the South Station Railroad Yard. The first part of this segment runs from Kneeland Street down to the Rail Yard (Ref. 8). It is a 1200 foot section of 78" pipeline with a capacity of 127 MGD and this part of the fourth segment is expected to be completed in 1985 as part of the MBTA project work in the Railroad Yard. The remaining part of this segment runs from Harbor Towers down to Kneeland Street. Design work on this section has been almost completed and construction is expected to be completed by the end of 1987. This final part will be 4000 feet of 78" pipeline intended to serve the downtown area. It will have a capacity of 43 MGD (Ref. 8) as compared to the current 5-9 MGD (Ref. 2). The Boston Water and Sewer Commission is currently preparing design packages to initiate funding for various parts of this final segment (Ref. 1).

The Boston Water and Sewer Commission is also conducting discussions with the Beacon Companies who will construct the portion of the new ESI along the Rowes Wharf area as part of the new development in that area. Also, in conjunction with this wharf development, a separate storm sewer system will be developed for Rowes Wharf. This storm drainage system will also extend back under the Atlantic Avenue and the Central Artery to the Purchase Street area bordering the Fort Hill Square Site (Ref. 1).

By comparing the capacity numbers listed above for the old and new ESI and BMI segments it is clear that this new pipeline will significantly improve sewer performance along the Inner Harbor. The Boston Water and Sewer

Commission expects operation of the new ESI, along with the current inspection and maintenance program, to eliminate all dry weather overflows, including the large one at BOS-060 (Central Wharf). In addition, the new line will decrease the volume and frequency of storm-related CSO. As discussed in the O'Brien and Gere report (Ref. 2), this action alone will improve water quality significantly in the Inner Harbor.

Plans for System Improvements at Deer Island Treatment Plant

The MDC is currently in the process of upgrading the Deer Island Treatment Plant in two stages in accordance with Judge Garrity's Procedural Order (City of Quincy vs. MDC, et al) (Ref. 9). The first stage is an immediate upgrade to improve pumping capacities at the plant. This program is intended to prevent situations where failure of pumping equipment at Deer Island leads to increased discharges at CSO facilities and the Moon Island outfall. This stage is intended to be complete by 1988.

The second stage is a complete construction of a new facility to increase treatment capacity. This program will extend into the mid 1990's.

Plans for System Improvements at Combined Sewer Overflows

The MDC is currently in the process of planning and implementing a major program to treat and/or limit discharges from combined sewer overflows throughout the MDC system. Within the next five years MDC plans to complete CSO treatment facilities which will eliminate discharges of raw sewage at Tenean Beach, Malibu Beach and Constitution Beach, as well as along a portion of the Charles River and the Mystic River in Somerville (Ref. 13).

A second program, expected to be completed over the next seven years (Ref. 10), will include 17 combined sewer overflow projects. These projects are a combination of storage and treatment facilities designed to reduce the major, chronic sources of pollution in Boston Harbor.

Among these projects is the Fort Point Channel CSO Treatment Facility. This facility will have a major impact on the Inner Harbor by significantly reducing pollutant loads to Fort Point Channel. Treatment will include screening, swirl concentrators and disinfection. When this project is completed, the significant pollutant loading which enters Fort Point Channel at BOS-070 will be greatly reduced, with significant improvement in water quality in the Inner Harbor as a result (Ref. 2, Ref. 13)

In a third phase of the CSO improvements, another 8 CSO improvement projects will be completed within the next 10 years. These three groups of CSO facilities scheduled for completion over the next 10 years will result in significant improvements in Boston Harbor water quality (Ref. 2, Ref. 6, Ref. 13).

5.1.4 Project Sewer Connections

Expected Waste Volumes

The sanitary sewage load for International Place is estimated, in accordance with Massachusetts Department of Environmental Quality Engineering guidelines, to be 75 gallons per day for every 1,000 square feet of office space. Phase I (South Tower) will include approximately 1,100,000 square feet of space and Phase II (North Tower) will add 700,000 square feet of space.

The sanitary sewage loads can be estimated as follows:

$$\begin{array}{rcl} \text{Phase I: } 1,100,000 \text{ sq.ft.} \times \frac{75 \text{ gallons per day}}{1000 \text{ sq. ft.}} = & & \\ & & 82,000 \text{ gallons per day} \end{array}$$

$$\begin{array}{rcl} \text{Phase II: } 700,000 \text{ sq.ft.} \times \frac{75 \text{ gallons per day}}{1000 \text{ sq. ft.}} = & & \\ & & 53,000 \text{ gallons per day} \end{array}$$

Retention Tank

The design and operation of the sewer system for the project has been an ongoing process involving the proponent and the Boston Water and Sewer Commission. These discussions have been directed towards determining appropriate mitigation measures for use by the project in light of the current sewer capacity problems in the site area and to assure that the project is compatible with other recent activities in the area (e.g. the Rows Wharf project). An initial mitigation measure required by the Commission is the use of a system for retention and timed release of the sanitary waste. Such systems are required by the Commission for all new developments with wastewater discharges of 10,000 gallons per day or more into the sewer system tributary to the ESI. The system entails collecting all sanitary waste in holding tanks located at below grade levels for discharge into the sewer system during periods of low tide. As previously discussed, tidal inflow during high tide due to broken or improperly operating tidegates contributes to surcharging of sewer lines in the waterfront area. The use of a retention tank and discharging at low tide will mitigate the project's impact on this problem.

A separate tank is being designed for each phase of development of the International Place development. The Phase I (South Tower) storage tank is a waterproof concrete tank with a capacity of approximately 82,000

gallons. This capacity provides the ability to store an entire day's sewage load.

The storage tank will be equipped with a triplex pumping system and a programmable tide clock controller. The triplex pump system provides for alternating pump operation among the three pumps. Each pump has a capacity of 350 gpm. The triplex design operates one pump at a time ensuring both longer pump life and constant backup capability. The pumps have been sized, and the tide clock controller provided, to enable complete discharge of the holding tank during low tides.

The pump capacity of 350 gpm is based on the requirement to pump out the retention tank during each four-hour low tide period. This requires a pumping rate as follows:

$$\frac{82,000 \text{ gallons}}{4 \text{ hours} \times 60 \text{ minutes per hour}} = 342 \text{ gpm}$$

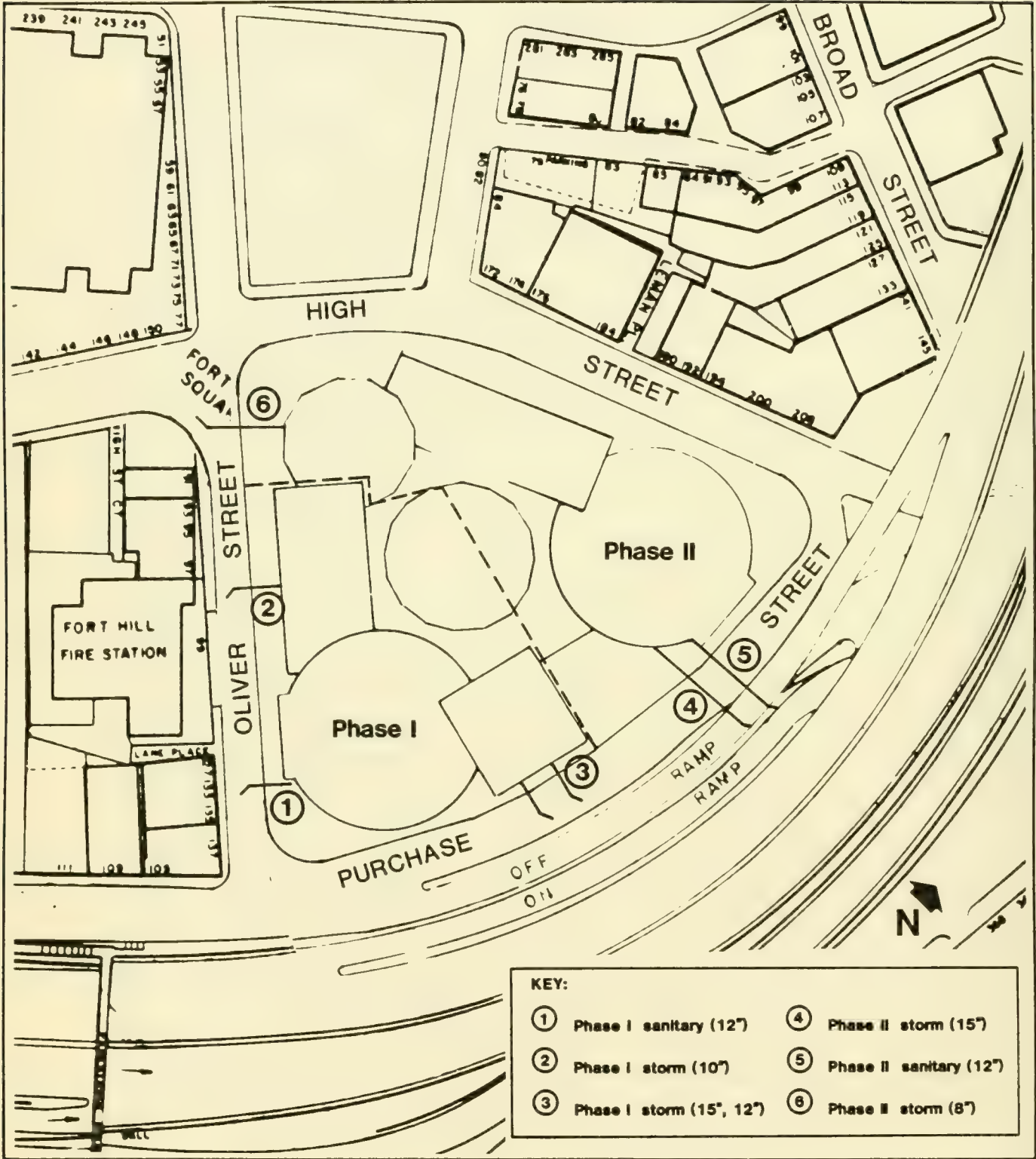
A second similar storage tank will be constructed, if necessary, for the second phase of development. The holding tanks and tidal clock are intended to minimize the impact of the project's sewage load upon the existing system until the New East Side Interceptor is in operation. Current Boston Water and Sewer Commission policy indicates that this type of system will no longer be required when the new interceptor is in operation because of the large increase in capacity that this will provide (43 MGD versus the current 5-9 MGD). However, with the system in place, the concept can continue to be used, if deemed necessary, with alterations to allow discharge after work hours, or on some other schedule determined by the Commission, should there continue to be a need to minimize peak flows in the area.

Sanitary Sewer Connections

An initial proposal for sanitary wastewater sewer connections was developed for preliminary project planning. This proposal is shown on Figure 5.1.7. This proposal called for a sanitary connection to Oliver Street for the Phase I (South Tower) development and a sanitary connection to Purchase Street for the Phase II (North Tower) development.

This initial proposal was used as a discussion basis with the Boston Water and Sewer Commission. After further review by the proponent and the Commission and consideration of plans for the New East Side Interceptor and the Rowes Wharf development, additional mitigation measures were developed to assist the Commission with its plans for sewer improvements in the Rowes Wharf area. Specifically, the Commission intends to have the Purchase Street sewer become part of a separate storm water system that will discharge directly to the Harbor in the vicinity of Foster's Wharf. For this reason, the proponent intends to direct all site storm water to Purchase Street where it will be able to be directly discharged to the Harbor upon the completion of the Rowes Wharf development, expected 1986-1987. This concept requires that no sanitary wastewater enter this portion of the system. Consequently, the Phase II sanitary connection is now proposed to be made to a combined sewer junction at Broad Street rather than to the Purchase Street sewer. According to the Commission, this will also help balance flows in the combined sewers serving the area. This drainage will require approximately 150 feet of additional sewer line from the North Tower to reach the Broad Street tie-in. Figure 5.1.8 and Table 5.1.5 present data on the revised sanitary sewer connections.

Figure 5.1.7 Initial Sewer Connection Plan



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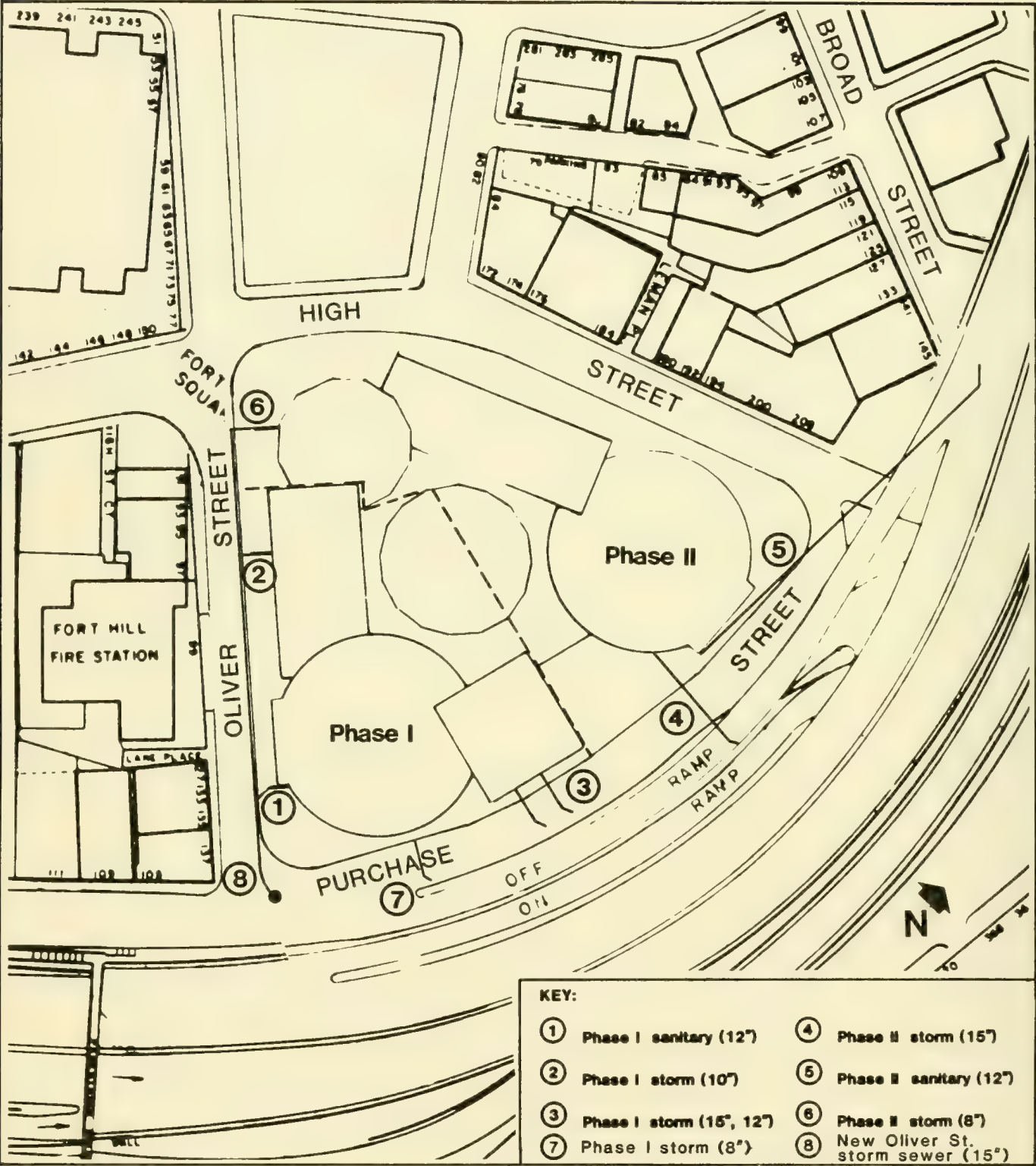
Storm Sewer Connections

To further assist the Commission in its efforts to separate storm and sanitary sewage, the proponent will construct a separate storm sewer in Oliver Street. This storm sewer will be a 15 inch line connecting to the Purchase Street sewer at the intersection of Oliver and Purchase Streets. This new line will convey storm runoff from two storm connections serving the site (see Figure 5.1.8) plus runoff in Oliver Street itself. The remaining storm runoff from the site will be directed to the Purchase Street sewer through three connections on that side of the site. As a result, all storm runoff from the site, as well as that from Oliver Street itself, will enter the proposed separate storm water system that will discharge directly to the Harbor. Currently, this storm water enters the overtaxed combined sewer system leading to the ESI. Removing the storm water from this system represents a significant mitigation measure. Table 5.1.6 presents data on the storm connections.

Abandoned Sewer Lines

The Boston Water and Sewer Commission has approved the abandonment of existing 18" x 12" combined sewers beneath the old High Street extension and Belcher Lane (see Figure 5.1.1). With the abandonment of this section of the sewer, temporary provisions will be made to handle drainage from the existing expressway ramp until the new expressway ramp is built along Purchase Street. The connection will continue to be to the Purchase Street sewer as it currently is. Drainage from the new ramp will be collected into the Purchase Street sewer thus allowing even more of the project area's drainage to be directly discharged into the Harbor.

Figure 5.1.8 Revised Sewer Connection Plan



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TABLE 5.1.5

SANITARY SEWER CONNECTIONS

I. Phase I (South Tower) - 82,000 Gal/Day

Oliver Street

12" connection with a peak flow of 350 GPM to a point 110 feet northwest of Oliver-Purchase intersection.

II. Phase II (North Tower) - 53,000 Gal/Day

Broad Street

12" connection with a peak flow of 250 GPM to a point approximately 570 feet northeast of Oliver-Purchase intersection.

TABLE 5.1.6

STORM SEWER CONNECTIONS*

Total Site Area - 115,301 Sq.Ft.

I. Phase I (South Tower) - 68,321 Sq.Ft.

A. Oliver Street

10" connection draining 8,300 Sq.Ft. of the site plus 3,700 Sq.Ft. of sidewalk to a point 260 feet northwest of Oliver-Purchase intersection. Design storm discharge rate is 1.09 cfs. (Note: New Oliver Street storm sewer will also carry 1.54 cfs from 15,000 Sq.Ft. of area from Oliver Street itself).

B. Purchase Street

15" connection draining 34,438 Sq.Ft. to a point 240 feet northeast of Oliver-Purchase intersection. Design storm discharge rate is 3.13 cfs.

12" connection draining 20,583 Sq.Ft. to a point 260 feet northeast of Oliver-Purchase intersection. Design storm discharge rate is 1.87 cfs.

8" connection draining 5,000 sq. ft. to a point 120 feet northeast of Oliver-Purchase intersection. Design storm discharge rate is 0.45 cfs.

TABLE 5.1.6 (cont.)
STORM SEWER CONNECTIONS

II. Phase II (North Tower) - 46,980 Sq.Ft.

A. Oliver Street

8" connection draining 10,000 Sq.Ft. to a point 360 feet northwest of Oliver-Purchase intersection. Design storm discharge rate is 0.91 cfs.

B. Purchase Street

15" connection draining 36,980 Sq.Ft. to a point 420 feet northeast of Oliver-Purchase intersection. Design storm discharge rate is 3.36 cfs.

* Storm water runoff has been calculated using the Rational Method, $Q = CIA$ where

Q = peak storm discharge rate

C = runoff coefficient

I = average rainfall intensity

A = area of runoff

In this case, C was assumed to be 0.9, representing the impervious nature of the site. The value of I in this case is 4.4 inches per hour, the 15 year storm with 10 minute time of concentration for Boston, as required by the Boston Water and Sewer Commission.

5.1.5 Project Impact

Oliver Street Combined Sewer

The existing Oliver Street combined sewer carries flow from the site in two different directions (see Figure 5.1.2) due to an elevation break point located about 350 feet northwest of the Oliver-Purchase Street intersection. There are no available data on flows in the sewer. However, because the sewer starts at the site, the only flows entering this 20" x 16" combined sewer (calculated capacity of 3,000 gpm) along the southerly direction on Oliver Street will be the 350 gpm (peak flow) from the Phase I (South Tower) sanitary connection. There will be no connections from the proposed project entering the sewer along Oliver Street flowing in the northerly direction.

At Purchase Street, the existing Oliver Street combined sewer dumps into a 72" round pipe that carries sewage from the site and other street sewers (serving 70 acres of Boston in the Summer Street and Essex Street areas) under the Central Artery and Atlantic Avenue to the East Side Interceptor. The capacity of this 72" line is 75 million gallons per day (Ref. 2), its peak flow during severe storm events. Average and peak daily dry weather flows were 3.8 and 7.6 million gallons per day, respectively, in 1982 (Ref. 11). These are expected to increase to an average of 4.7 and a peak of a 9.2 million gallons per day by the year 2010. The project's 82,000 gallons per day would add about 2 percent to the average 1982 flow. The combined sanitary flows are well within the 75 million gallons per day capacity in the 72" line.

Currently, there are periodic dry weather overflows at BOS-062, the outfall serving the Oliver Street line. These overflows are due to surcharging in the ESI. Project sanitary flows in Oliver Street will not

contribute to dry weather overflows once the new ESI is completed and the surcharging problem is eliminated. The BWSC expects the New ESI to be completed prior to the completion of Phase I of the International Place development. If the ESI replacement is not completed, there will be potential for some part of the Phase I sanitary flows to reach the Harbor directly, along with sanitary wastewater from the contributors, during the infrequent periods of dry weather overflow at BOS-062. It is not possible to quantify this but the BWSC has indicated that dry weather overflows at BOS-062 are relatively infrequent (Ref. 1). There is a greater potential for sanitary wastewater from International Place to reach the Harbor directly during wet weather periods. However, International Place sanitary wastewater will be discharged only about 6 to 8 hours each day, during low tide periods. This decreases the frequency with which storm events could cause the project's wastewater to reach the Harbor.

Once the new Oliver Street storm sewer is constructed by the proponent, there will be no storm runoff from the site entering the existing Oliver Street combined sewer. Since such storm runoff currently does enter this system, the proposed project will decrease peak runoff flows in this system by directing drainage from over three acres of impervious area into the new, separate storm system. This should assist in decreasing the amount of wet weather overflow of combined sewage at BOS-062, the CSO serving Oliver Street (see Figure 5.1.2).

Purchase Street Sewer

There will be no sanitary wastewater connection to the Purchase Street sewer (calculated capacity of 2,000 gpm). The result is that the sewer can be tied into a separate

storm sewer system planned for the Rows Wharf development (see Figure 5.1.2). The Boston Water and Sewer Commission expects this separate storm system to be operational well before the completion of the Phase I development (Ref. 1). As a result, project storm water discharges to Purchase Street will not contribute in any way to combined sewer overflows.

Broad Street Sewer

The Broad Street sewer (calculated capacity of 16,000 gpm) will receive the Phase II sanitary wastewater flow of 53,000 gallons per day at a peak flow of 250 gpm. The Commission requested that the Phase II sanitary connection be made at this point in order to keep the Purchase Street sewer reserved for storm water only and because of available capacity in the Broad Street sewer. Flows into the Broad Street sewer eventually reach the ESI at the Milk Street regulator near Central Wharf (see Figure 5.1.2). The combined sewer system in this area currently has significant surcharging due to the previously described hydraulic constraint that exists at the junction of the new ESI section north of Harbor Towers and the old ESI section south of Harbor Towers (Ref. 1, Ref. 2). This problem, and the resulting dry weather overflows at BOS-060, will be eliminated when the ESI replacement project is completed in 1987. The Phase II sanitary flow will not be generated until approximately 1990 so there is little chance of this flow contributing to overflows.

By way of comparison, the sewer system of which the Broad Street sewer is a part, served a daytime population of 54,000 in 1980 (Ref. 2). O'Brien and Gere estimates that this corresponds to a dry weather sewer flow in this system of 4,050,000 gallons per day (Ref. 2). The

Phase II flow that will enter this system is 53,000 gallons per day or 1.3 percent of the calculated flow.

East Side Interceptor

The current problems with the East Side Interceptor result in frequent storm-related combined sewer overflows and occasional dry weather overflows in the area. Overflows potentially affected by the project include BOS-060, 062, 063, 064, 065, 068, 069 and 070 (see Figure 5.1.3). Until the ESI replacement is complete, there is some potential for additional flows from new development, no matter how small or well-mitigated, to contribute to the frequency and volume of overflows. Because of the lack of data on the system performance, actual quantification of the project's impact on the current system can only be done in a relative way by comparing expected project flows to pipe capacity and calculated flows as shown above. However, the Boston Water and Sewer Commission, as discussed in Section 5.1.3, is firmly committed to completing the ESI replacement (Ref. 1, Ref. 7). When this is accomplished, the Commission expects dry weather overflows in the area to cease and the frequency and volume of wet weather overflows to decrease significantly (Ref. 1). This is supported by the Commission's policy of requiring the use of retention tanks only until the ESI replacement is operational. The replacement will have a capacity of 43 million gallons per day compared with the current 5-9 million gallons per day in the area (Ref. 2, Ref. 8). The total International Place sanitary sewage flow will be 135,000 gallons per day. This is 0.3 percent of the capacity in the new ESI. Clearly, the International Place project will have no significant potential for contributing to the volume and frequency of overflows once the ESI replacement project is complete.

It should also be noted that mitigation actions taken at International Place will result in the elimination of 100 percent of the site's storm water from the ESI. For a typical storm event of a half inch of rain in an hour, this results in approximately 650 gallons per minute of storm water that goes directly into the Harbor via the BWSC storm lines, leaving more than enough room in the ESI for the 600 gallons per minute of sanitary wastewater that results from both Phase I and Phase II operations.

The Metropolitan District Commission and the Boston Water and Sewer Commission are relying upon the Boston interceptor replacement project, additional CSO improvement projects and the Deer Island upgrading to result in significant improvements in Boston Harbor water quality (Ref. 5). The CSO overflow problem is one of huge dimensions. The plan that the MDC and Commission are pursuing represents the massive level of effort that is required to improve water quality in the Harbor in a significant manner. Continued implementation of this plan (as described in Section 5.1.3) will lead to the following water quality benefits (Ref. 6):

- o Elimination of dry weather overflow
- o Reduction in frequency and volume of untreated CSO discharges by 75%.
- o Maintenance of designated water uses (swimming, boating, fishing, etc.) all but a very few days per year.
- o Reduction of pathogenic bacteria by 99%, thereby resulting in attainment of Water Quality Standards.
- o Improved control of floating and settleable materials.

Based upon discussions with the Boston Water and Sewer Commission, and review of available references and data, it is anticipated that the International Place project, with appropriate mitigation measures to be implemented by the proponent (including the retention tank and the separate storm sewer), should not contribute in any measurable way to the volume and frequency of combined sewer overflows. Consequently, the project is compatible with long term plans to improve water quality in Boston Harbor.

5.1.6 Mitigation Measures Project-Specific

The following mitigation measures will be implemented by the project proponent.

1. Use of the latest, most efficient plumbing fixtures including limited flow taps (3 gpm vs 5 gpm) and toilets that require about 60% the water of the more conventional equipment, as required by the state plumbing code.
2. Use of a sewage retention tank with the capacity to store an entire day's sanitary wastewater. The tank will be equipped with a triplex pumping system and a programmable tide clock controller. Sanitary wastewater will be pumped into the combined sewer system only during periods of low tide. This will reduce loads on the system during high tide periods when surcharging caused by tidal inflow is a problem.
3. Elimination of the proposed sanitary connection on Purchase Street. This will allow the Purchase Street sewer to be tied into the separate storm sewer system

being developed as part of the Rowes Wharf project. The result will be that 100 percent of the storm runoff from the site will be routed directly to the Harbor, thus reducing load on the combined sewer system. Currently, all site runoff goes into the combined sewer.

4. Construction by the proponent of a new, separate storm sewer in Oliver Street. This sewer will carry all storm runoff from the site and Oliver Street to the Purchase Street storm sewer and on to the Harbor as described in item 3, thus eliminating existing storm discharges to the overburdened combined sewer system.

In addition to these measures, the proponent is prepared to operate the programmable pumping system on any feasible schedule proposed in the future by the Boston Water and Sewer Commission. This could include time of day pumping to avoid peak daytime flow periods.

System-Wide Measures

Constraints imposed upon individual new developments can mitigate localized problems and can assist in achieving overall improvement to water quality in the Harbor. However, real improvement can only be made with large-scale efforts to upgrade the combined sewer system operation. The MDC and Boston Water and Sewer Commission are currently undertaking a number of such improvements (Ref. 5):

1. Replacement of the East Side Interceptor. This project will be completed by the end of 1987. It will increase the ESI capacity in the site area from the current 5-9 million gallons per day to 43 million gallons per day (Ref. 8). It will eliminate the

hydraulic constraint currently causing surcharging in the vicinity of Central Wharf (BOS-060) (Ref. 1). It is also expected to eliminate dry weather overflows and reduce wet weather overflows at all the combined sewer overflow outlets that would be impacted by the project (Ref. 1, Ref. 2).

2. Inspection and maintenance of tidegates and regulators. The Commission instituted, in 1980, a program to inspect all tidegates and regulators at least two times each quarter. Maintenance on broken tidegates at Central Wharf (BOS-060) and Long Wharf (BOS-058) is expected to be completed in 1985. This will reduce tidal inflow that currently causes surcharging in the combined sewer system in that area (Ref. 1).
3. Completion of the Combined Sewer Overflow Recommended Plan. This comprehensive program includes the installation of new CSO treatment facilities for screening and disinfecting CSO discharges, replacement of tidegates and regulators, sewer separations, and storage facilities. The goal of this 10-year program is to eliminate dry weather overflows and reduce the discharge of untreated CSO by 75 percent. Included in this program is the construction of the Fort Point Channel CSO Treatment Facility which will greatly reduce CSO pollutant discharges to Boston Harbor. This facility is scheduled for completion within 7 years (Ref. 5, Ref. 6, Ref. 13).
4. Upgrade Deer Island Treatment Plant pumping capacity (Ref. 9, Ref. 10).

Conclusion

Taken in total, the project-specific and system-wide mitigation measures represent a significant minimization of the potential impact of International Place. The project-specific mitigation measures will be sufficient to minimize project impacts until ongoing system-wide improvements are completed (most importantly, the replacement of the East Side Interceptor), thereby essentially eliminating any potential negative impact of the project on combined sewer overflows or water quality in Boston Harbor.

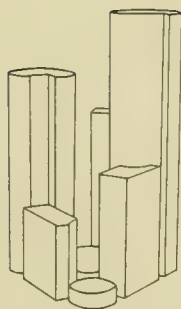
REFERENCES FOR SECTION 5.1 SEWER SYSTEMS

- Ref. 1 Discussions with Boston Water and Sewer Commission.
- Ref. 2 "Combined Sewer Overflow Project, Inner Harbor Area Facilities Plan," MDC, December 1982, prepared by O'Brien & Gere Engineers, Inc.
- Ref. 3 "Report to the MDC Sewerage Division on Discharges from Moon Island", April 1984, Camp Dresser & McKee, Inc.
- Ref. 4 "DEIS Third Harbor Tunnel Project, Interstate 90, Appendix 7", U.S. DOT, MDPW, December 1982.
- Ref. 5 "Combined Sewer Overflow Project Summary Report on Facilities Planning", MDC, April 1982.
- Ref. 6 "Combined Sewer Overflow Project Environmental Impact Report", Camp Dresser & McKee, January 1982.
- Ref. 7 "A Sewer Improvement Program for Boston", Boston Water and Sewer Commission.
- Ref. 8 Discussions with Camp Dresser & McKee, Inc.
- Ref. 9 "Procedural Order, City of Quincy vs. MDC, et al", Paul J. Garrity, Justice of the Superior Court.
- Ref. 10 Discussions with Metropolitan District Commission.
- Ref. 11 Data provided by Boston Water and Sewer Commission, from the Boston Facilities Plan Project, prepared by Metcalf and Eddy, February 1984.

Ref. 12 "MDC Sewerage Division 64th Annual Report," June
30, 1983.

Ref. 13 "Proposed Capital Program for MDC Sewerage," MDC,
February 27, 1984.

Energy Analysis



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9. Energy Analysis

9.1 Introduction

Throughout the development of International Place, energy efficiency has been a significant consideration. Cosentini Associates, the mechanical engineers for the project, have been charged with designing HVAC and mechanical systems that incorporate advanced technology in energy conservation technology.

The engineers were instructed that simply meeting the applicable energy consumption guidelines offered by the Massachusetts State Building Code Provisions for Energy consumption, and other accepted industry standards such as ASHRAE 90-75, was not enough. Instead the specific objectives of the energy design and analysis process has been:

- o To minimize building energy demand
- o To minimize wasteful elements of summer solar gain.
- o To consider the feasibility of utilizing renewable energy sources
- o To minimize fossil-fuel consumption
- o To maximize energy efficiency based upon the anticipated life-cycle costs of the building energy systems.

9.2 Building Energy Conservation Measures

There are three sub elements that have been considered in the design of the building envelope. These are window designs, solar orientation and thermal insulation.

9.2.1 Window Design Treatment

The architects and engineers began their window treatment-energy studies with a review of projected building use.

It was concluded that office will be by far, the predominant use, with a substantial amount of retail space as well. These uses will lead to heavy daytime usage with much less intense evening usage during hours of darkness. With this knowledge a decision was made to rely heavily on natural lighting. Natural lighting is provided by generous use of windows, supplemented by ample glazing in the specialty areas, including the courtyard and the street frontage area. In total about 40% of the facade will be glazed. This high degree of natural lighting enables the engineers to reduce interior lighting energy requirements (see Section 9.5) to 1.7 watts/square foot. This compares favorably with the Massachusetts Code level of 2.5 watts/square foot and constitutes 32% savings in energy consumption with no loss in lighting quality.

In selecting windows, the architects and engineers have been sensitive to all energy issues. Accordingly the windows will be double glazed and combine reflective coatings with tinted glass panes. The double glazing doubles the R values over single glazed windows, conserving energy devoted to either space heating or air conditioning. The dual-pane reflective glass also prevents excessive solar gain reducing air conditioning requirements, and contribute to sound insulation.

9.2.2 Solar Orientation

The International Place buildings have been situated to make best use of the site. The placement and shaping of the buildings have resulted in energy efficiency benefits. First the cylindrical shape reduces the amount of surface area for the facade. The cylinder has 11% less surface area than a square box of the same floor area. Reduced surface areas mean less heat transfer from the building to the environment and less area to be insulated. Resultant

savings in space heating and air conditioning demand are apparent. In addition, the cylindrical surfaces provide for a more balanced spreading of solar gain as compared to a rectangular shape. The sun's angle is normal (perpendicular) to smaller sections of the cylindrical facade at any given time, and the solar angle changes more gently through the day. This will spread air conditioning demands more evenly over the day, resulting in lower peak air conditioning demand. The lower demand is reflected directly in energy consumption, and indirectly in the ability to size the air conditioning equipment to the lower peak demand.

9.2.3 Thermal Insulation

The "skin" of the building will consist of the double glazed window, described above, along with 1/4" spandrel glass and 1" thick granite slabs. The masonry elements will be insulated by providing both an air space and 2" of rigid insulation board. The International Place wall structure will have an R value of 8, a good value for high rise commercial construction. The total surface area will have a combined heat conductivity of about .275 BTU/hour-square foot-⁰F. This heat transfer level is a noteworthy 17% below the ASHRAE 90-75 requirements for type B buildings. With these conductivity values only 14.7% of the total annual energy consumption is devoted to space heating*, and approximately 16% is required for cooling.

* Most of the demand for heat occurs during daylight hours. During the daylight hours the space heating equipment is augmented by other activities that create heat as a by-product. During the day lighting fixtures, office equipment and appliances provide heat. In addition solar gain and body heat from the building occupants contribute to the incidental heating. The resultant is lower space heating demand, but higher air conditioning demands than one expects for residential or low-rise low occupancy structures.

9.3 HVAC Design Considerations

Cosentini Associates has undertaken some system specific feasibility studies that have lead to the selection of the HVAC system for International Place. Systems based upon on-site fossil fuel combustion, solar energy applications, and an all electric system were reviewed.

9.3.1 Fossil Fuel System

The project engineers considered utilizing both fuel oil and gas fired systems to provide space heating at International Place. Fuel oil fired boiler designs were found to have a number of problems. First the oil fired burners would require 100,000 gallons of fuel oil annually. This volume of fuel oil would require substantial on-site storage capacity and between 20 and 30 fuel oil deliveries per heating season. Fuel oil storage on site would use valuable space for tanks and pipes and would require additional safeguard systems as well as an exhaust venting system which would add to local pollutant levels. In short the fuel oil system has high capital costs, inordinate space requiements, is incompatible with the general design of the complex, and is inconvenient from a maintenance and operations standpoint. These shortcomings are balanced by no offsetting advantages, making a fuel oil burner feasible but not advisable.

A natural gas-fired boiler system was found to be similar to the oil-fired system in most respects. The gas system is different from the oil system in two areas. First it eliminates the fuel storage issue, but second the fuel cost and supply reliability questions are more severe. Past shortages have been documented and with price de-regulation substantial price variance (upward) is possible. As with oil the disadvantages make a gas system feasible but undesirable.

9.3.2 Solar Energy

The International Place design uses passive solar energy in the form of direct solar gain through glazed areas. This solar gain serves to lessen space heating requirements. At the same time project engineers considered the feasibility of active solar systems. The engineers concluded that the site is simply too small for solar collectors. There is insufficient area, including available roof tops, to place a system that could supply a reasonable fraction of the space heating or hot water demand of the project. Furthermore local climatology matches poorly with solar heating requirements. In December, January, February and March when nearly all the space heating demand takes place solar potential is poor. Shorter days and more cloud cover during these months reduce solar heat generation. Therefore, such a system would be in addition to, rather than in place of, a conventional system. The architects advise that roof tops are necessary for other mechanical systems. In conclusion solar systems, including collectors, pumps and piping equipment, can supply only a small fraction of the International Place heating requirement, and that on an unreliable basis. Therefore, costs of a solar system cannot be justified.

9.3.3 Electric Heating

The last system considered was electric resistance heating, the system being used more and more frequently in Boston's commercial developments. Electric heat appealed to the engineers and architects alike. Its appeal was based upon its demonstrated reliability, the lower capital cost of electric resistance heating systems, its reduced space demands, and its "good fit" with the short heating

season for International Place. Such systems have minimal maintenance problems.

The mechanical engineers talked with Boston Edison and received assurance that the utility company is ready and able to meet the total electrical demands of the project, including heating. An all electric development will receive the benefits of a lower electric rate, not only for the space heating, but for total electrical consumption.

9.3.4 Life Cycle Costing Comparison

In addition to studying the general characteristics of each of the energy sources, Cosentini Associates has undertaken a life cycle costing comparison for the alternative energy supplies. The comparison addresses the Phase I portion of the development for which design is more advanced. The comparison is equally valid for the Full Build option. The alternatives considered were:

1. Hot water coils and gas boiler.
2. Hot water coils and oil boiler.
3. Electric resistance heating.

Each system was assumed to be coupled with a variable air volume (VAV) ventilation system. A number of assumptions regarding operating procedures, schedules, and design conditions were made. These assumptions were:

Occupancy: Weekdays from 8 AM to 6 PM at 100%
level (100% = 100 sq. ft./person).

Saturdays from 9 AM to 1 PM at 100%
level, all other times at 5%.

Lights:	Same schedule as occupancy (100% level = 1.7 Watts/sq. ft.).
Appliances:	Same schedule as occupancy (100% level = 1 Watt/sq. ft.)
Cooling Equipment:	Available 7 AM to 6 PM weekdays, 8 AM to 1 PM Saturdays.
Heating Equipment:	Available at all times.
Minimum Outside Air:	Follows same schedule as occupancy (100% = .1 CFM/sq. ft.).
Fans:	Available same hours as cooling equipment. Off at all other times except during setback mode when heating is required.
Setback Schedule:	Cooling - 75 ^o during occupied hours. 85 ^o during non-occupied hours. Heating - 70 ^o during occupied hours. 60 ^o during non-occupied hours.

Table 9.1 is the completed energy systems cost summary. The annual energy consumption, annual energy cost, and incremental installed first cost are detailed for the three alternatives. The annual energy consumption is based on gross conditioned square feet (for Phase I, 1,087,000 sq. ft.).

Table 9.1 shows that the electric heating method is clearly the most economical from a life cycle standpoint. Oil heating has both a higher annual cost and a higher first cost. The current annual energy cost with gas heating is \$19,000 less, but the incremental first cost is \$750,000 greater for the gas-boiler system. It would take 39 years to recover this added first cost through fuel savings. The current value of \$19,000 per year savings is approximately \$185,000 for a 39-year at a 10% discount rate. These values confirm that the electric system best meets project needs based upon current costs. The engineers feel that the potential savings may be even greater as gas and oil prices escalate; while electrical suppliers switch fuel sources (oil, coal, nuclear) according to pricing and availability.

9.4 Characteristics of the Selected HVAC System

The all-electric HVAC system for International Place consists of the electric resistance heating, described earlier, a chilled water air-conditioning system, and a variable air volume (VAV) ventilation system.

Electric resistance heat will be supplied primarily via coils in the VAV system. Supplementary perimeter electric heating will also be provided and distributed overhead through a perimeter linear diffuser. In the office and retail spaces, all heat accumulated in the ceiling return-air plenums from lights and other electrical and mechanical systems will be circulated to heat the building perimeters.

The chilled water refrigeration plants will be located in the lower levels of the high rise towers. The central cooling plant for Phase I will be located on the second floor of the building above the loading docks and parking

TABLE 9.1

INTERNATIONAL PLACE
ENERGY SYSTEMS COST SUMMARY
OFFICE BUILDING & RETAIL

	<u>VAV With Gas Boiler</u>	<u>VAV With Oil Boiler</u>	<u>VAV With Electric Resistance Heating</u>
Annual Energy Consumption (BTU/SF Gross-Yr)	51,600	50,000	49,364
Annual Energy Cost (\$)	\$1,521,000	\$1,567,000	\$1,540,000
Differential Installed, First Cost (\$) With Electric as Base	+ 750,000	+ 825,000	0

Note: Payback for Alternate 1 = $\frac{\$750,000}{19,000}$ = 39 yrs.

Payback for Alternate 2 = (Loss)

entrances in order to minimize its intrusion on pedestrian activities. The central cooling plant for Phase II will go below grade, adjacent to Purchase Street. The cooling towers for each phase will be placed on floors 44 and 33, respectively, of the two high-rise towers. The cooling towers will be placed out of sight, behind the parapets, rather than protruding from the rooftops.

Each floor will have a separate chilled water air-handling unit serving zoned VAV fan powered units for the floor areas on the building perimeter and VAV terminal units for the building interior floor areas. The VAV

equipment balances the need for outside air with recirculated inside air. Outside air will be vertically distributed to the fan rooms on each floor. Fresh air intake fans will be located at the upper and lower levels of each of the high rise towers.

A less energy intensive condenser water free-cooling system will be provided for a portion of the cooling season. The condenser water free-cooling cycle will save energy as refrigeration compressors can be shut down when outside temperatures in the spring and fall permit natural cooling. During these periods, chilled water will be obtained directly from the cooling towers without the use of mechanical refrigeration.

The zoned VAV system has distinct advantages over conventional HVAC systems. It provides for local climate control on demand. It incorporates natural heating and cooling by mechanically mixing and supplying air volumes to areas with heating or cooling requirements. The result is an HVAC system in which the relationship between building occupancy and climate control energy consumption are quasi-linear - that is the system can respond efficiently to localized demands whether they be special type occupancy or just partial occupancy.

9.5 Lighting

The lighting for the building will consist primarily of overhead space lighting with a minimal amount of direct and indirect specialty lighting for special tenant needs and public areas. The space lighting will be provided by the newest high-efficiency parabolic-louvre light fixtures with high efficiency ballasts. These lights combine the high efficiency of fluorescent lighting with the no-glare diffusion of a parabolic reflector returning the "wasted light". This lighting system, in conjunction with the

natural lighting, requires only 1.7 watts per square foot to provide a comfortable lighting level.

All space lighting will be activated by local switching systems on a room-by-room basis.

9.6 Total Energy Demand

Since International Place is an all-electric design (with an emergency back-up generator) its energy consumption may be measured exclusively in kilowatt hours (KWH). The estimated total annual energy consumption for Phase I is approximately 17,000,000 KWH or 15.5 KWH/square foot. Annual consumption for the completed International Place will be approximately 29,000,000 KWH. A breakdown of the total expected energy use is provided in Table 9.2. As shown in the table, lighting, appliances, cooling, heating and air handling are the major energy consuming activities.

TABLE 9.2
INTERNATIONAL PLACE
ESTIMATED ELECTRICAL CONSUMPTION

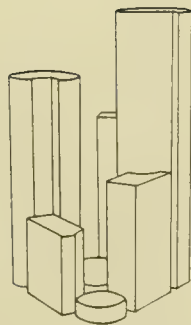
Project Component	Annual Consumption KWH X10 ³
Office Building	
Lighting	5,650
Appliances	3,054
Cooling	2,596
Heating	2,443
Air Handling	1,527
Retail	
Lighting	194
Appliances	52
Cooling	108
Heating	35
Air Handling	41
Garage	
Lighting & Miscellaneous	659
Air Handling	517
Total	16,876*

*= 15.5 KWH/sq.ft. of conditioned space (1,087,000 sq.ft.)
= 49,300 BTU/sq.ft. exclusive of garage

9.7 Conclusions

The International Place mechanical systems are well designed and energy efficient. The major energy consuming facilities have been chosen on life cycle costs rather than original capital costs. The result is a coordinated all-electric design that exceeds accepted building codes and industry standards for energy efficiency.

Natural Resources Analysis



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10. Natural Resources Analysis*

10.1 Existing Conditions

The site for the International Place development is an urban location, near the waterfront, on the edge of Boston's Financial District. The site is covered by impervious surfaces in the form of outdated development. There is neither wildlife nor vegetation on the development parcel. The only natural resources subject to change with the project are the subsurface geohydrology characteristics. Since groundwater is not used as a source of potable water in Boston, primary concerns for changes in geohydrology deal with structural support characteristics that might be affected by excavation and foundation development for the project.

During recent subsurface explorations, the following soil and rock sequence was revealed: fill deposits over lodgement till over bedrock. A generalized description of the major soil strata and the underlying bedrock is given in the following paragraphs:

10.1.1 Bedrock

Bedrock, known locally as the Cambridge Argillite, underlies the site. The rock has been kaolinized, possibly by hydrothermal alteration, and is generally a soft, moderately to extremely fractured, white kaolinized

* Taken from the following documents:

1. Report on Preliminary Evaluation of Foundation Design and Construction Requirements International Place at Fort Hill Square, Boston, Massachusetts
Haley & Aldrich, Jan, 1983.
2. Influence of Groundwater Levels, Haley & Aldrich, April, 1984.

Argillite with numerous pits produced by leaching of soluble minerals. The argillite is capped by a layer of hard, white sandstone. Bedrock was encountered at approximately EL. -105.

10.1.2 Lodgement Till

During late Pliestocene glaciation, lodgement till was deposited at the site in the form of a drumlin below the area known as Fort Hill. The lodgement till is composed of a heterogeneous mixture of grain sizes from clay through boulders. Laboratory tests indicate that in general the till is described as a gray sandy CLAY or clayey SAND with some silt and trace to little gravel.

The density of the till increases with depth, and below approximately El. -40, the number of blows required to drive the sampler was generally in excess of 100 blows for six inches or less of penetration. Visual examination of the samples below approximately El. -40 indicates that the amount of sand and gravel increases. Although boulders were not cored in the borings, it is highly probable that both cobbles and boulders will be present throughout the till deposit, with increased frequency below El. -40.

Within the till deposits, clay-rich zones, as well as one layer of silty coarse to fine sand (at El. -35), were penetrated in several of the borings. These zones of clay, silt or sand are randomly located within the overall body of the till, and appear to have been deposited at discontinuous layers, pods or lenses.

10.1.3 Fill

The original topographic configuration of Fort Hill has been modified by man. Starting in 1866, the hill was

excavated and used for landfill in adjacent Atlantic Avenue. By 1872, the hill had been leveled. Consequently, any archeological investigation of the site is considered unnecessary.

Successive periods of development in the vicinity of Fort Hill Square have resulted in a relatively thin stratum of miscellaneous fill materials overlying the till. The fill varied in thickness from 5 ft. to 9 ft. in the five borings, and generally consists of a brown coarse to fine SAND with varying amounts of silt, clay, gravel and brick.

In general the geologic characteristics of the site are well suited to the proposed project. The soils have ample bearing capacity to support high rise construction and the site appears to be free of subsurface water problems.

10.2 Influence of Project on Groundwater Levels

The current design includes a five-level deep (to El. -20) basement below the high rise structures for parking. This parking will encompass the entire below grade area of the site. The foundation system will be a concrete mat and spread footings. The foundation will bear directly on the dense, glacial till soils below the lowest garage level.

Based on subsurface reports done for the project, other available data and past experience in the area, Haley & Aldrich has recommended that a maximum groundwater level of El.-12 be assumed for design purposes. Therefore, basement floors and walls below the groundwater table must be designed to either 1) resist full hydrostatic pressures, or 2) control the pressures by an underdrainage and pumping system. For this project, the latter method is planned.

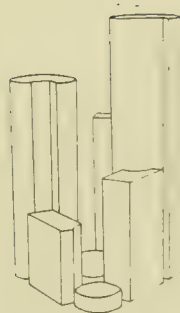
The lowest-level floor slabs are to be totally relieved of hydrostatic pressures. The floor will be designed as a slab-on-grade, bearing on a pervious drainage layer in which underfloor drains are installed. The voids between the foundation wall and the lateral earth support system will be backfilled with impervious materials to control seepage around the perimeter.

Based on investigations to date, the soils engineers have concluded that the installation of underdrains below the floor will not significantly lower the groundwater levels beyond the site boundaries.

A more detailed investigation of the soils has been initiated in order to further assess the impervious nature of the on-site glacial till soils. A major part of this investigation is to install observation wells and piezometers in several of the new test borings in order to monitor groundwater levels in a more detailed manner. Following completion of the detailed test boring program and interpretation of the final results, it is planned to install several groundwater observation wells in locations adjacent to the site. These observation wells, installed prior to the start of construction, will serve to monitor groundwater levels prior to, during and following the excavation, foundation, and major structural construction time periods. The current plan for the location of the wells calls for them to be at several accessible points, surrounding the site, at distances up to approximately 400 feet away from the site/boundaries.

These wells and their ability to be monitored will allow the project's geotechnical engineers to track groundwater levels and any changes in these levels throughout the construction process. This will allow possible adverse changes in the levels to be identified and alleviated before adverse impacts propagate.

Comments and Responses



Boston Redevelopment Authority

Stephen F. Coyle/Director

November 8, 1984

Fort Hill Square Associates
c/o Mr. Donald Chiofaro
The Chiofaro Company
One Post Office Square
Boston, MA 02109

Dear Mr. Chiofaro:

As part of the Boston Redevelopment Authority's review of the International Place development, the Authority has reviewed the Environmental Impact Report which you have submitted to us pursuant to our environmental review requirements for major development projects.

International Place at Fort Hill Square (the "Project") is a mixed-use development project to be constructed by Fort Hill Square Associates ("FHSA") on the 2.6 acre site bounded by High, Oliver and Purchase Streets in Boston's downtown financial district (the "Project site"). The Project site consists partly of privately owned land and partly of land now owned by the City of Boston. In accordance with a Sale and Construction Agreement dated May 30, 1984 by and between the City of Boston and FHSA, the Project is subject to design review by the Boston Redevelopment Authority ("BRA") acting as agent for the City and in its municipal capacity as the Planning Board of the City of Boston under St. 1960, C. 665, §12.

As the BRA is acting with respect to the Project only in its municipal planning board capacity and not as a state redevelopment authority under Chapters 121A and 121B of the General Laws, the actions of the BRA are not subject to the Massachusetts Environmental Protection Act, G.L. c. 30, SS et seq. Nevertheless, the BRA has required the developer to prepare a report analyzing all environmental impacts of the Project. The scope of the environmental report was set forth in a March 28, 1984 letter from the Authority, a copy of which is attached hereto for reference.

An environmental report was submitted by FHSA in May 1984. On May 27, 1984 the BRA published notice in the Boston Herald of the availability of the report, scheduling of a public hearing on the report for June 8, 1984, and the opportunity to submit written comments until June 26, 1984. A public hearing was conducted on the environmental report by the BRA Board on June 8, 1984. The comment period was subsequently extended until July 27, 1984.

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The development team and the BRA design review staff have been engaged, since designation of the developer last October, in design measures that would mitigate possible adverse impacts, particularly in the areas of shadow, wind, and traffic.

Concerning massing and density, substantial size reductions have taken place in the design development stages of the project. Initially, the taller of the two towers was located at the intersection of High and Purchase Streets. It has been moved to the Oliver and Purchase Street corner of the site where it will have less shadow impact on the Financial District, the Broad Street area, and public areas along the waterfront. The massing of the project originally called for two towers of 51 and 44 stories. They have been lowered to 46 and 35 stories respectively. In the spring of 1984, the massing of the lower tower stood at 36 stories, but shadow studies indicated that a one-story reduction would have beneficial sunlight impacts near the intersection of Milk and India Streets resulting in the final 35 story height. The rectangular elements, originally at 31 and 15 stories were also reduced to 27 and 11 stories respectively. In deference to the Chadwick Leadworks building on High Street, the lowest element of the International Place project is now opposite.

In comparison with the original proposal, the density of the approved massing has dropped dramatically. The developer's initial proposal called for an FAR of nearly 23. In the designation, it was reduced to 16. In square feet, this means a reduction of 320,000 feet from an original 2,170,000 to 1,850,000 square feet. The project as presently outlined in the design review documents equates to a project of 1,657,000 square feet of building area and an FAR of approximately 14.3.

It must also be noted that, as a result of the above reduction in building massing through the environmental and design review process, the views from other buildings will benefit from the widened space between the towers, satisfying a design guideline minimizing view blockage.

With regard to improving pedestrian flow and access, the developer and the Authority have widened sidewalks to a minimum fifteen foot width. Pedestrian access to the project has been improved by increasing the number of entrances to the courtyard and office elements and by aligning them with the entrances of surrounding buildings as well as with the end of Batterymarch Street. The development team is also continuing to test wind mitigation steps in the form of canopies and trees to see what effect they will have on pedestrian wind.

Concerning roadway and traffic improvements, International Place was originally designed leaving the existing High Street ramp from the Central Artery in place. As a condition of tentative designation, the development team has agreed to cooperate in relocating this ramp to a realignment along Purchase Street, a step considered by the Authority and State officials to be beneficial to downtown traffic patterns.

Mr. Donald Chiofaro

November 8, 1984

Additionally, the traffic flow in the immediate area will be improved as a result of design changes that move all truck docks underground, eliminating truck queueing along Purchase Street. The approved design also has resulted in relocating public parking access from the corner of High and Purchase Streets to a preferred location on Purchase Street. Traffic exiting from the underground service and parking areas of the project will be from four lanes rather than an original ten, resulting in a smoother integration of project traffic into the city pattern.

The Authority herein affirms that the Environmental Impact Report for the above-referenced Project, dated May 1984, does comply with the scope of impacts described in the Director's letter of March 28, 1984, and is prepared in accordance with the procedures of the Authority and other requirements concerning the protection of the environment applicable to the Project.


The Report also has been made available to other public agencies, including the MEPA office, and to interested individuals and groups which have requested copies. As a result of this review, we have received a number of comments on the EIR. A copy of the Authority comments are attached for your attention.

Promptly after this letter, you should submit to the BRA responses on the EIR. In preparing your responses, you should work with appropriate Authority staff. In addition, since you also are requested to submit a more limited Impact Report to MEPA, your responses to the comments should reflect the scope and comments concerning the MEPA document.

A final Environmental Impact Report, including the approved Environmental Impact Report and your responses to the comments, should be submitted to the Authority, which report must assure the Authority that all feasible means and measures heretofore recommended by the Authority to avoid or minimize adverse environmental impacts have been adopted.

In closing, I would like to reaffirm that the Authority's design review process, which has led to numerous mitigating measures, is an ongoing process and that further design review, in accordance with the Authority's standard design review procedures, will be required for the second phase of the project.

Sincerely
BOSTON REDEVELOPMENT AUTHORITY



Stephen Coyle
Director

International Place - Comments on Draft Environmental Impact Report

Noise

Future noise levels resulting from the project (including traffic generated) do not appear to be a significant problem since they are projected to be less than or only slightly greater than, existing levels and are within the normal range for downtown areas.

Transportation Analysis

Since the submission of the EIR to the Boston Redevelopment Authority, an expanded Transportation analyses was submitted to the State, the BRA assumes that level of analysis in the MEPA EIR is the basis for a final BRA EIR and therefore submits the following comments pertaining to the MEPA EIR.

1. In general, the transportation section in the MEPA EIR is an improvement over the same section in the BRA draft. Many of the deficiencies found in the BRA document have been corrected, except as noted below. The major improvement is that now the no-build and build scenarios are comparable, since both assume the relocation of the High Street off-ramp and thus the impact of the project can be more readily seen (as opposed to trying to determine what is due to circulation changes and what to the project).
2. It is still not clear whether existing trips to and from the site have been eliminated from future conditions or not, and whether the International Place traffic is the total traffic generated by the project or is new traffic (in addition to the traffic now generated by the site. This is not explicitly stated in the EIR. As an example of this problem, the A.M. peak-hour generation of International Place is given as 770 vehicles (Table 22). But according to Table 24 (which obviously includes some double-counting) peak-hour project-generated traffic is considerably lower and certainly does not reflect the fact that the project includes a 827-car garage. What happens to the majority of the project-generated traffic? Or is the analysis only talking about net increases?
3. On Page 8, A.M. and P.M. peak hours should be identified.
4. Figure 5 shows the Federal Street garage with 950 spaces whereas Page 13 states 900 spaces; this should be clarified.
5. (Table 1, footnote) - If there are 177 surface spaces on the site (Figure 5) then 660 (garage) and 177 equals 837 spaces, not 827. Which (827, 837, 887) is used for the analysis?
6. On Page 16, it should be noted that the Dewey Square Tower clearly falls within a 2,000-foot radius of the project site (see Figure 7).

7. The trip numbers on Table 7 should be verified. For example, Route 301, 301-1 is shown as having a bus leave during the P.M. peak period every 2 minutes, which is very questionable.
8. On Page 54, it should be noted that the P.O. Square Garage project has completed its State environmental review process (EIR not required).
9. A map indicating trip distribution percentages by highway route would be helpful (Page 83).
10. On table 24, why is the P.M. peak hour traffic for Atlantic Avenue north of Northern Avenue higher without the project than with?
11. On Figure 16, the route from the High Street ramp does not agree with the text (P. 94) (Broad Street is not shown).
12. Neither Table 26 nor Figure 17b. shown any change in LOS (or V/C ratio) for Atlantic Avenue/State Street during the A.M. peak between the No-Build and Build conditions (Page 104).
13. On Page 111 (last paragraph), should "off ramps" should be "on-ramps".
14. On Page 119, it is neither accurate nor reasonable to say that there is no congestion on the Arborway Line during rush hours.
15. It is not clear that all 1,500 parking spaces at North Station would be public (Page 127). A substantial number (800) currently are programmed to be reserved for MGH.
16. Does the traffic (LOS) analysis take into account the proposed pedestrian signal at Atlantic Avenue/Purchase Street?

Air Quality

The air quality analysis presented to the BRA has been expanded and modified in the DEIR submitted to the State. A revised air quality analysis based on the State DEIR should be included in the final BRA EIR. Therefore, the following comments are submitted concerning the MEPA DEIR Air Quality analysis.

1. On Page 6, peak-hour time is not given in the Transportation Section (also, there is no Section 5.2, which is repeatedly referred to in the text).
2. On Page 7, it does not appear that the speeds used in the analysis (see Tables A.5 and A.6 correspond to the conditions predicted at the analyzed intersections. Speeds used for these sites should be less than or equal to 10 mph (As noted in the Transportation Analysis comments, most of these intersections actually have LOS F).

3. As in the Transportation Section, it is unclear whether the increase in CO emissions is due to a net increase in traffic because of the project or to the total project-generated traffic (Page 177). This should be clarified.
4. On Pages 18-22 the parking facility analysis (Build) appears to consider only cars entering and existing the garage. Have trucks also been included in the analysis?
5. Since both air intakes and the exhaust vent will be located on Purchase Street, what precautions will be taken to prevent exhausts from being drawn into the air intakes?

Pedestrian Wind Analysis

The wind impact analysis indicates that there may be increased and uncomfortable winds created at some locations. At over half of the locations tested, winds will increase. The project enhances and the Phase I park area are indicated as locations which will be extremely windy.

In the Final EIR, the wind analysis must be augmented to consider specific mitigation measure testing. The May 31, 1984 BRA design development approval letter required that mitigation measures be studied in an effort to mitigate the adverse impacts of winds at street level.

Historic/Archaeological Impacts

There are several impact areas where effects on the adjacent historic properties are potentially adverse. Specifically, some shadow effects, pedestrian level winds, and traffic impacts may adversely impact the historic properties adjacent to the site. Therefore, the comments presented for those specific sections are referenced as they relate to the historic area.

The final EIR should also include support for the conclusion that no archaeological investigations are warranted.

Utilities

No discussion of, or commitment to, conservation measures to reduce water demand/sewerage generation is contained in the EIR. Since there is a potential for a deficiency in the City's water supply by 1990, investigation of, and commitment to, conservation measures must be included in the Final EIR.

The Boston and Sewer Commission noted that sufficient information to determine the project's effects on its system was lacking, particularly with respect to the storm drainage system. More detailed data respecting peak and average demands, adequacy of the existing utility systems, and overflow potential are included in the MEPA EIR. The following comments are presented relating to the State DEIR on sewer systems:

1. On Page 4, the text states that the northern part of the Oliver Street sewer is 24" x 18"; Figure 5.1.5 shows 24" x 16". Which is correct?

2. The Purchase Street sewer routing on Figure 5.1.2 does not correspond to the text description of the route Page 6).
3. On Tables S.1.2 and S.1.3, standards/criteria need to be given for comparative analysis purposes. There is nothing which describes the water quality or what parameters are being exceeded.
4. The project includes 1,700,000 sf. of office space (not 1,800,000 sf.) and 100,000 sf. of retail space/restaurants. How do retail/restaurant sewerage loads compare to office loads and what impact will these have on total loads (pp. 23-24)?
5. If O'Brien and Gere use a factor of 75 gal/person (rather than 75 gal./1,000 sf. office space) to estimate areawide dry weather flows, and since there are approximately 5 persons per 1,000 sf. of office space, is sewerage flow from the project being underestimated (pp. 32-34)?

Energy

This section of the EIR is acceptable, no environmental issues have been identified during the review.

Natural Resources

Although the text did not indicate any substantial environmental problems, backup data and studies were only referenced and not included in the EIR. For the Final EIR, the following should be included:

1. The results of more detailed soils investigations noted in the Draft EIR, including monitored groundwater levels (the actual studies also should be included as an appendix).
2. A plan indicating the location of the groundwater observation wells to be installed prior to project construction.
3. More detailed information and analysis of the potential effect on surrounding buildings of a lowering of groundwater levels.
4. A description of the measures which will be taken during construction should a change in groundwater levels occur or other problems arise.

Boston Redevelopment Authority - Additional Comments on DEIR

1. Comment: "In general, the transportation section in the MEPA EIR is an improvement over the same section in the BRA draft. Many of the deficiencies found in the BRA document have been corrected, except as noted below. The major improvement is that now the no-build and build scenarios are comparable, since both assume the relocation of the High Street off-ramp and thus the impact of the project can be more readily seen (as proposed to trying to determine what is due to circulation changes and what to the project)."

Response: No response was necessary.

2. Comment: "It is still not clear whether existing trips to and from the site have been eliminated from future conditions or not, and whether the International Place traffic is the total traffic generated by the project or is new traffic (in addition to the traffic now generated by the site. This is not explicitly stated in the EIR. As an example of this problem, the AM peak hour generation of International Place is given as 770 vehicles (Table 22). But according to Table 24 (which obviously includes some double counting) peak hour project-generated traffic is considerably lower and certainly does not reflect the fact that the project includes a 827 car garage. What happens to the majority of the project generated traffic? Or is the analysis only talking about net increases?"

Response: The discussion related to Table 24 centers on the net change in volumes on various roadways as a result of the project and does account for the site parking garage.

3. Comment: "On page 8, AM and PM peak hours should be identified."

Response: The FEIR identifies the peak hours on page 8.

4. **Comment:** "Figure 5 shows the Federal Street garage with 950 spaces whereas Page 13 states 900 spaces; this should be clarified."

Response: The figure has been corrected to show 900 spaces in the Federal Street garage.

5. **Comment:** "(Table 1, footnote) - If there are 177 surface spaces on the site (Figure 5) then 660 (garage) and 177 equals 837 spaces, not 827. Which (827, 837, 887) is used for the analysis?"

Response: The existing site contains 660 spaces in the garage and 167 surface lot spaces for a total of 827 spaces which was the figure used in the analysis. All typographical errors have been corrected in the final report.

6. **Comment:** "On page 16, it should be noted that the Dewey Square Tower clearly falls within a 2,000 foot radius of the project site (see Figure 17)."

Response: It should be clear that the Dewey Square Tower falls within the 2,000 foot contour line shown. The text has been modified to show this.

7. **Comment:** "The trip numbers on Table 7 should be verified. For example, Route 301, 301-1 is shown as having a bus leave during the PM peak period every 2 minutes, which is very questionable."

Response: The data shown in the trip summary table represents two routes (301, 301-1) and the route frequencies were initially obtained from the MBTA Systems Planning unit during the Dewey Square TSM study. As noted, 57 outbound trips are scheduled during the PM peak period (2 hours) of which approximately

half represent Route 301 while half represent 301-1. These data which indicate 4 to 5 minute headways per route were reviewed in response to the comment and as a result, the data were correct.

8. **Comment:** "On page 54, it should be noted that the Post Office Square Garage project has completed its State Environmental Review Process (EIR not required)."

Response: This was noted in the final report text on page 52.

9. **Comment:** "A map indicating trip distribution percentages by highway route would be helpful (page 83)."

Response: Figure 12A was prepared which illustrates the regional trip distribution pattern of trips to and from the site.

10. **Comment:** "On Table 24, why is the PM peak hour traffic for Atlantic Avenue north of Northern Avenue higher without the project than with?"

Response: The PM peak hour traffic for Atlantic Avenue north of Northern Avenue is not higher without the project than with as was shown in the DEIR due to a typographical error. This was corrected in the final report.

11. **Comment:** "On Figure 16, the route from the High Street ramp does not agree with the text (page 94) (Broad Street is not shown)."

Response: Figure 16 was corrected in the final report.

12. **Comment:** "Neither Table 26 nor Figure 17b shows on any change in LOS (or V/C ratio) for Atlantic Avenue/State Street during the AM peak between the No-Build and Build conditions (page 104)."

Response: During the AM peak hour, it is not anticipated that traffic volume through this intersection will increase significantly, particularly with respect to the critical movements. As a result, the AM peak hour operating conditions should be minimally affected as a result of the project.

13. **Comment:** "On page 111 (last paragraph), should "off ramps" be "on-ramps"."

Response: The text in the final report was corrected.

14. **Comment:** " On page 119, it is neither accurate nor reasonable to say that there is no congestion on the Arborway Line during rush hours."

Response: The text was modified to reflect this comment. Although the v/c analysis indicates sufficient capacity there are periods which are indicative of congested conditions. However, it should be noted that with the relocation of the Orange Line, the Arborway Line will benefit substantially as a 40 percent shift of riders from the Green Line to the Orange Line is projected by the MBTA.

15. **Comment:** "It is not clear that all 1,500 parking spaces at North Station would be public (page 127). A substantial number (800) currently are programmed to be reserved for MGH."

Response: No response was necessary. Comment noted.

16. **Comment:** "Does the traffic (LOS) analysis take into account the proposed pedestrian signal at Atlantic Avenue/Purchase Street?"

Response: The LOS analysis at this intersection accounted for pedestrian crossings at this location under concurrent walk phases, which is the practice under existing conditions.

Air Quality

1. Comment: "On Page 6, peak-hour time is not given in the Transportation Section (also, there is no Section 5.2, which is repeatedly referred to in the text)."

Response: Overall the peak-hour in the project area is approximately 7:30-8:30 in the morning and from 4:30-5:30 in the afternoon. This is documented in the Transportation Analysis on page 8. (The Section 5.2 repeatedly referred to in the air quality analysis is the Transportation Analysis Section.)

2. Comment: "On Page 7, it does not appear that the speeds used in the analysis (see Tables A.5 and A.6) correspond to the conditions predicted at the analyzed intersections. Speeds used for these sites should be less than or equal to 10 mph (As noted in the Transportation Analysis comments, most of these intersections actually have LOS F)."

Response: It is true that LOS F conditions are associated with average travel speeds through an intersection of 10 mph or less. The speeds shown on page 7 of Appendix A (Tables A.5 and A.6) however do not represent the average

speed for cars through these intersections. Those values are the speeds at which cars approach the end of the queue (if one exists) before they decelerate. Thus, these values represent the maximum speeds a car will reach in the free-flow gaps between congested intersections. Once a vehicle reaches the end of a queue, the emissions from deceleration, idling, and acceleration are calculated separately in the Volume 9 model using the V/C ratio which is in essence the LOS. We believe the range of 20-28 mph is a fair representation of peak-hour vehicle approach speeds (outside the queue) as defined above.

3. Comment: "As in the Transportation Section, it is unclear whether the increase in CO emissions is due to a net increase in traffic because of the project or to the total project-generated traffic (Page 177). This should be clarified."

Response: The increase of predicted CO concentrations at receptor locations in the Air Quality Analysis represent net CO increases as a result of additional project area traffic generated by International Place. Net CO increases were only predicted since these levels are required for comparison to the applicable Massachusetts and National Ambient Air Quality Standards (NAAQS) for CO.

4. Comment: "On Pages 18-22 the parking facility analysis (Build) appears to consider only cars entering and exiting the garage. Have trucks also been included in the analysis?"

Response: The air quality analysis for the parking facilities did include trucks in the study. A conservative estimate of 10.5 percent medium and heavy-duty trucks was assumed in calculating emissions from the parking garage.

5. Comment: "Since both air intakes and the exhaust vent will be located on Purchase Street, what precautions will be taken to prevent exhausts from being drawn into the air intakes?"

Response: Good engineering practice requires that an air intake be at least ten feet from any contaminant source. The air intake along Purchase Street for the International Place parking garage are all well over forty feet from the exhaust vent as well as on different sides of the mechanical room building. These distances are sufficient to allow for dilution of the parking garage exhaust.

Historic/Archaeological Impacts

1. Comment: "The final EIR should also include support for the conclusion that no archaeological investigations are warranted."

Response: In the May 1984 BRA Report (Section 10.1.3) it was explained that

"The original topographic configuration of Fort Hill has been modified by man. Starting in 1866, the hill was excavated and used for landfill in adjacent Atlantic Avenue. By 1872, the hill had been leveled. Consequently, any archaeological investigation of the site is considered unnecessary."

This statement was compiled by HMM Associates after it had reviewed pertinent site history documentation. Included in the HMM review was an informal discussion between HMM and the Massachusetts Historical Commission staff. In that conversation a State archaeologist confirmed that the site had been previously altered to the extent that there should be no concern about potential for disturbing archaeological resources. This leads to the conclusion that there is no reason to compile any further archaeological data.

Utilities

1. Comment: "On page 4, the text states that the northern part of the Oliver Street sewer is 24" x 18"; Figure 5.1.5 shows 24" x 16". Which is correct?"

Response: A recent inspection by the Boston Water and Sewer Commission revealed the pipe size to be 20" x 16". The figure and text have both been revised in the Final EIR to reflect this.

2. Comment: "The Purchase Street sewer routing on Figure 5.1.2 does not correspond to the text description of the route (Page 6)."

Response: The Purchase Street sewer routing described in the text and on the figure have both been revised to be consistent and to reflect recent information obtained from the BWSC.

3. Comment: "On Tables 5.1.2 and 5.1.3, standards/criteria need to be given for comparative analysis purposes. There is nothing which describes the water quality or what parameters are being exceeded."

Response: A new table (Table 5.1.4) has been added to the Final EIR to show applicable Massachusetts Water Quality standards.

4. Comment: "The project includes 1,700,000 sf. of office space (not 1,800,000 sf.) and 100,000 sf. of retail space/restaurants. How do retail/restaurant sewerage loads compare to office loads and what impact will these have on total loads (pp. 23-24)?"

Response: Massachusetts Department of Environmental Quality Engineering regulations require the use of the following factors for estimating sanitary wastewater generation:

Office space:	75 gallons/day/1000 sq.ft.
Retail space:	50 gallons/day/1000 sq.ft.
Restaurants:	35 gallons/day/seat

Project wastewater flows were estimated based upon 1.8 million square feet of office space as follows:

$$1,800,000 \text{ sq.ft.} \times \frac{75 \text{ gal/day}}{1000 \text{ sq.ft.}} = 135,000 \text{ gal/day}$$

If the retail and restaurant flows are considered the estimates are as follows:

Office space:

$$1,700,000 \text{ sq.ft.} \times \frac{75 \text{ gal/day}}{1000 \text{ sq.ft.}} = 127,500 \text{ gal/day}$$

Retail space:

$$70,000 \text{ sq.ft.} \times \frac{50 \text{ gal/day}}{1000 \text{ sq.ft.}} = 3,500 \text{ gal/day}$$

Restaurants (assuming 500 seats):

$$500 \text{ seats} \times 35 \text{ gallons/day/seat} = 17,500 \text{ gal/day}$$

$$\text{TOTAL} = 148,500 \text{ gal/day}$$

This estimate is within 10 percent of the original estimate and its use would have no effect on the impact of the project. The retention basins will be sized to hold on the order of 135,000 gallons but will be pumped out twice a day. The result is that the basins are essentially twice the size needed and easily able to accommodate variations of this magnitude.

5. Comment: "If O'Brien and Gere use a factor of 75 gal/person (rather than 75 gal/1,000 sf. office space) to estimate areawide dry weather flows, and since there are approximately 5 persons per 1,000 sf. of office space, is sewerage flow from the project being underestimated (pp. 32-34)?"

Response: The use of the factor of 75 gallons/day/1000 square feet is required by the Massachusetts Department of Environmental Quality Engineering to estimate sanitary wastewater generated by commercial office space. This factor is also approved for use by the BWSC to design the required retention tanks. The factor of 75 gallons/day/person used in the O'Brien and Gere report (EIR Ref. 2) appears to have been developed by O'Brien and Gere as an empirical number used to estimate wastewater discharges from a mixed use area of residential, commercial and industrial uses. Since residential and industrial uses (included in the O'Brien and Gere factor) generate larger amounts of wastewater per capital than office space (as International Place) the two numbers, which are used for different purposes, are not comparable. The O'Brien and Gere number is used in the EIR only as the best published data available to estimate wastewater generated from broad areas of the city, not from specific office buildings.

Natural Resources

1. Comment: "The results of more detailed soils investigations noted in the Draft EIR, (the actual studies also should be included as an appendix)."

Response: Haley and Aldrich, Inc. has been retained as geotechnical engineering consultant to the International Place project. In that capacity they have compiled detailed soils investigations for the Fort Hill Square site. Those investigations have been documented in the Report on Subsurface Investigations and Foundation Design Studies, International Place at Fort Hill Square, Boston, Massachusetts. The report is included, by reference, as an appendix to the FEIR. It has been submitted under separate cover.

2. Comment: "A plan indicating the location of the groundwater observation wells to be installed prior to project construction."

Response: A plan indicating the location of groundwater observation wells to be installed prior to project construction is attached. As shown, observation wells will be installed at six locations surrounding the subject site to monitor the water levels in the upper fill soils.

In addition to the observation wells, two piezometers will be installed in three of the six locations. The piezometers will be installed at depths of approximately 30 and 60 ft. below the ground surface. The purpose of

the piezometers is to monitor the piezometric levels in the glacial till stratum.

The observation wells will be installed at least one month prior to the start of excavation. After installation, the observation wells and piezometers will be monitored at least once a week until construction begins in order to establish a data base.

Once construction begins, a representative of Haley & Aldrich will monitor the contractor's foundation construction activities. The observation wells and piezometers will be monitored daily until footing construction is complete; then on a twice a week basis until the perimeter foundation walls are constructed to street level. Upon completion of the perimeter foundation walls, the wells and piezometers will be monitored at least twice a month for at least 6 months.

If no significant change in the water levels is noted in the 6 month period after construction, monitoring will be discontinued.

3. Comment: "More detailed information and analysis of the potential effect on surrounding buildings of a lowering of groundwater levels."

Response: As indicated in the Haley and Aldrich geotechnical report, in situ soil permeabilities were determined by performing falling head permeability tests in the bore holes.

The results indicate that the soil permeabilities ranged from 3.5×10^{-4} to less than 1×10^{-7} ft/min. Based on these results, it is likely that the piezometric levels in the glacial till soils will be lowered only slightly during and following construction. Because the glacial till soils are dense and relatively incompressible, settlement of the adjacent buildings, caused by the drop in the piezometric level, is expected to be negligible. During foundation construction, the water level in fill material is expected to be lowered somewhat, without adverse effects to surrounding property.

The perimeter foundation wall has been designed to maintain groundwater levels in fill materials which overlie the till. The typical wall detail has been included in the Haley and Aldrich report. By casting the

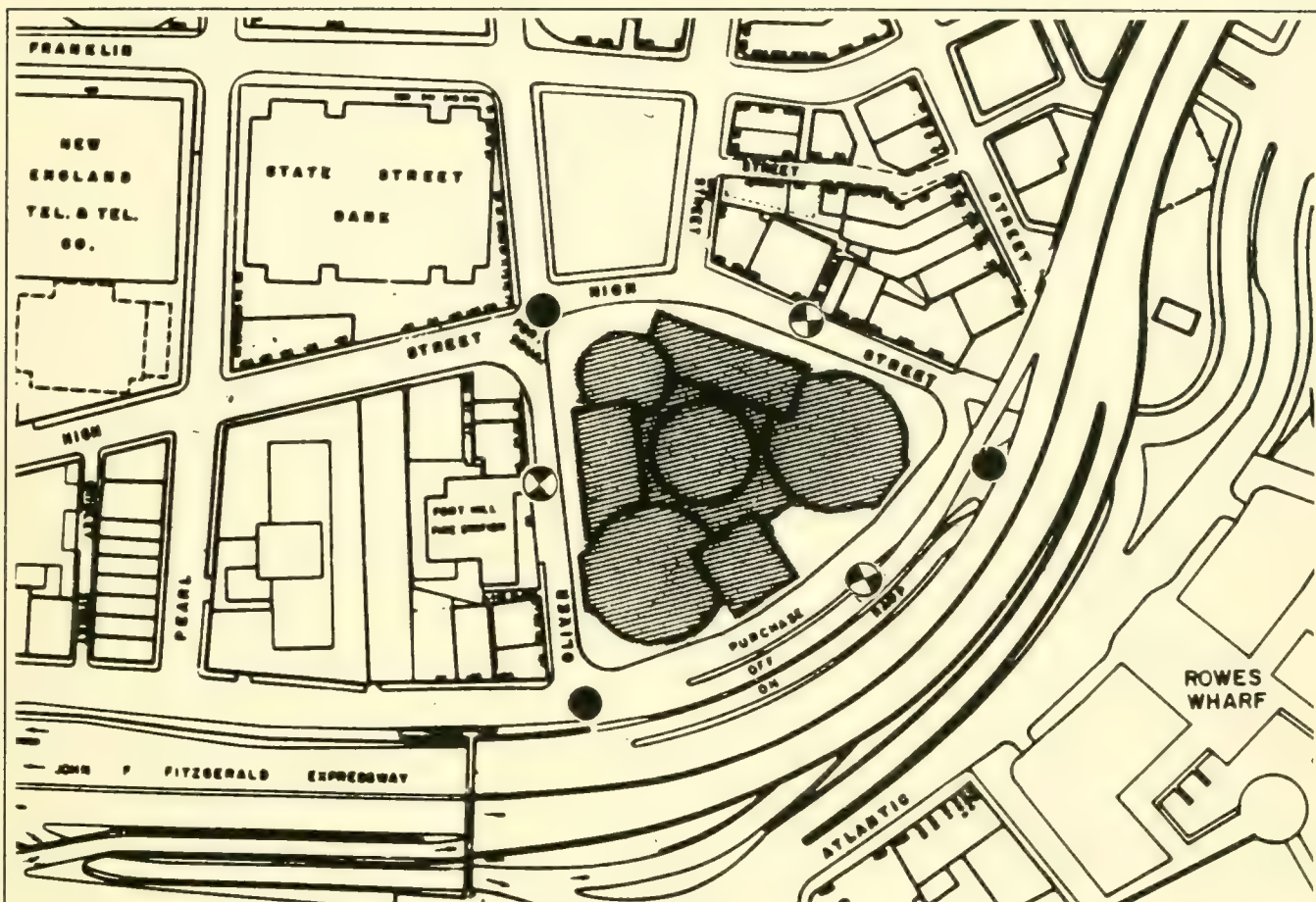
foundation wall against the lateral earth support system and constructing seepage cutoffs (or concrete seals) in the soldier pile and lagging system, downward seepage of groundwater along the outside face of the foundation wall to the underdrain system will be minimized.

4. Comment: "A description of the measures which will be taken during construction should a change in groundwater levels occur or other problems arise."

Response: In order to monitor the effects of foundation construction on groundwater levels as well as adjacent structures, Haley and Aldrich will:

- 1) Install observation wells and piezometers at the locations shown on the attached plan, and monitor water levels as discussed above.
- 2) Monitor adjacent structures along Oliver Street and the High Street off-ramp for possible lateral and vertical movements by installing a series of settlement pins on these structures. In addition, streets surrounding the site will also be monitored.

The monitoring program will provide an "early warning" to potential construction related movements. As previously discussed, a temporary lowering of the water level in the fill is not expected to cause any construction related movements. However, if it is determined that a change in the water levels due to the construction activities has caused possible unacceptable movement, a groundwater recharge system will be installed to raise the groundwater levels to their pre-construction elevations.



PLAN OF PROPOSED OBSERVATION WELL LOCATIONS

LEGEND

- ⊗ Approximate location of observation well/double piezometer installation.
- Approximate location of observation well installation.

NOTES

- 1) Observation wells and piezometers will be installed prior to the start of excavation.
- 2) Observation wells will be installed in each of the boreholes to monitor groundwater levels in the fill stratum.
- 3) Pneumatic piezometers will be installed at depths of approximately 30 ft and 60 ft from the ground surface in three selected boreholes to monitor piezometric pressures in the glacial till stratum.
- 4) Location of observation well and piezometer installations are preliminary only, pending clearance of utilities and other obstructions in the field.

International
Place
at Fort Hill

Haley & Aldrich
Cambridge, MA

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